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Office of Radiation Programs

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	ki'lo
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
A	ampere(s)	
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps-2.22×10^{12} dpm
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	3.527×10^{-2} ounces= 2.205×10^{-3} pounds
Hz	hertz	cycle per second
kVp	kilovolt peak	
m	meter(s)	39.4 inches=3.28 feet
m^3	cubic meter(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
mi	mile(s)	
ml	milliliter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g
r/min	revolutions per minute	
s	second	
yr	year	

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RADIATION DATA AND REPORTS

Volume 15, Number 2, February 1974

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In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

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U.S. ENVIRONMENTAL PROTECTION AGENCY

Russell E. Train, Administrator

Reports

A Radioactive Isotopic Characterization of the Environment Near Wiscasset, Maine: A Preoperational Survey in the Vicinity of the Maine Yankee Atomic Power Plant[1]

Dr. C. T. Hess, Dr. C. W. Smith, H. A. Kelley, and F. C. Rock[2]

An environmental radioactivity survey was conducted in the vicinity of the Maine Yankee Atomic Power Plant prior to the operation of this facility. Measurements of environmental radioactivity were made on samples of soil, sediment, well water, surface water, estuarine water, air particulates, air moisture, and precipitation.

Natural radioisotopes in the uranium and thorium series and potassium-40 were found in most of the samples. Cesium-137 also was found in some samples.

An environmental radioactivity survey in the vicinity of the Maine Yankee Atomic Power Plant (6.4 km south southwest of Wiscasset, Maine on Bailey Point) was conducted prior to the operation of this facility. The study employed standard surveillance methods as recommended by the Bureau of Radiological Health, U.S. Public Health Service (*1*). The study was designed to isotopically characterize the radionuclear environment in a quantitative and qualitative manner, establish a meaningful and useful background baseline to which data from future radiological studies can be compared, document average values for the radiation levels from various environmental media, and locate and identify any regions of "other than average character" or contributions to the background by "manmade" radionuclides.

Measurements of the radioactivity in the environment were made on soil, sediment, well water, surface water, estuarine water, air particulate, air moisture, and precipitation in the form of snow and rain.

Study design

The basic approach used in the study design was to employ modern standard methods of measuring environmental radioactivity in typical environmental media with emphasis on measuring individual isotopes. The study was divided into two parts. Field measurements were made employing a portable multichannel analyzer system. This system, along with appropriate support equipment, was used in the field to measure various environmental media in situ (*2-5*). Laboratory measurements on collected samples were carried out at the Northeastern Radiological Health Laboratory (NERHL), Winchester, Mass. This dual approach exercised a variety of standard surveillance techniques.

The scope of this survey encompassed the three zones of environmental media, terrestrial (soil and sediment), aquatic-estuarine (well water, surface water and estuarine water) and air (air particulate, air moisture and precipitation in the form of snow and rain). Sample locations were chosen in general to be as natural and undisturbed as possible, typical of the media they represent and reproducible in the sense that measurements can be repeated in the future at the sites used in this study (*6*). The study was 8 weeks in duration beginning June

[1] This work was carried out under Environmental Protection Agency Contract Number 68—01—0541.

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5, 1972 and ending July 28, 1972. The snow samples were taken March 11, 1972.

RADIONUCLIDES IN THE SOIL AND SEDIMENT

Soil and sediment field measurements

Radionuclides in the soil were measured at nine locations (figure 1). A sediment measurement was taken at Murphy's Corner, the location of a tidal mud flat of commercial importance to the local blood worm industry. A portable multichannel analyzer system was employed and consisted of a Northern Scientific, Inc. NS-710 multichannel analyzer powered by a Cornell-Dubilier Powercon sine wave inverter Model 12ESW25 and a 12 V.d.c., 96-amp-hour battery. The detector, a 5 cm by 5 cm NaI(Tl) crystal, was an integral crystal-photomultiplier assembly by Teledyne Isotopes, Inc., Model S-88I with 8.4 percent resolution at the cesium-137 photopeak. It was powered by a Northern Scientific, Inc., high voltage battery power pack NS-308 with the matched cable-base assembly NS-309. The detector was connected to the multichannel analyzer with 50 meters of coaxial cable (RG-59). A 45 kg lead shield, consisting of a cylinder 28 cm high and 18 cm in diameter with a 6 cm diameter concentric hole the full length of the cylinder, was used to house the detector for each field measurement. The shield was placed on the ground, the detector lowered into the shield, and a 3 cm-thick lead cap covered the upper end of the shield. The lower end of the shield was open to the soil so that the circular face of the detector was placed on the ground (a 3 cm insulating layer of plywood was used to protect the crystal from thermal shock). All field soil and sediment gamma-ray spectra were taken using this top shielded 2π geometry. It is felt that this geometry has two advantages: (1) it is reproducible, and (2) it is without bias in that it samples the soil in a nondestructive noncomponent manner. All field soil and sediment spectra were taken on half memory (512 channels) for 4000 seconds. At the end of two runs, the multichannel analyzer was returned to the Maine Yankee Environmental Studies Center at Bailey Point and the memory outputted into a model KSR-33 teletype, which provided a listing of the counts in each channel and a punched paper tape.

The information on the punched paper tapes was recorded on cards and the gamma spectra analyzed at the University of Maine Computer Center. The least squares method was used to obtain the best estimates of the amounts of each radionuclide present in each sample and an evaluation of the errors of these results. The program used was the Oak Ridge National Laboratory spectrum fitting program, Alpha-M (*7*). It employs the least squares method to analyze the data for which a "best fit" is mathematically computed, such that the sum of the squares of the deviations between the actual spectra, and the "best fit" is minimized. The program also uses automatic gain shift and automatic threshold shift routines to optimize the fit. The program works with a library of standard spectra from which it synthesizes the "best fit" spectra. The library used for the analysis of the soil and sediment field spectra was composed of standard spectra for potassium-40, cesium-137, the thorium-232 series, and the uranium-238 series.

Details of the calibration of this library of standards is contained in appendix A. Output from the program consists of the estimated amount of each standard spectra needed to synthesize the sample spectrum, the estimated error in the amount used for each library standard, the gain shift (if any) used to match the spectrum to the standards, the threshold or zero offset (if any) used to match the spectrum to the standards, the residuals for each channel, and a listing of suspicious channels whose residuals lie outside 2 standard deviations. In all cases, convergence was obtained in less than 20 iterations. The results of the analysis are listed in table 1.

In general, all spectra contained potassium-40. Furthermore, the spectra contained the natural decay series for thorium-232 and uranium-238. A significant amount of cesium-137, a nonnatural isotope, is contained in all spectra. The field measurements indicated no other isotopes.

Soil and sediment laboratory measurements

Soil samples were collected at Foxbird Island,

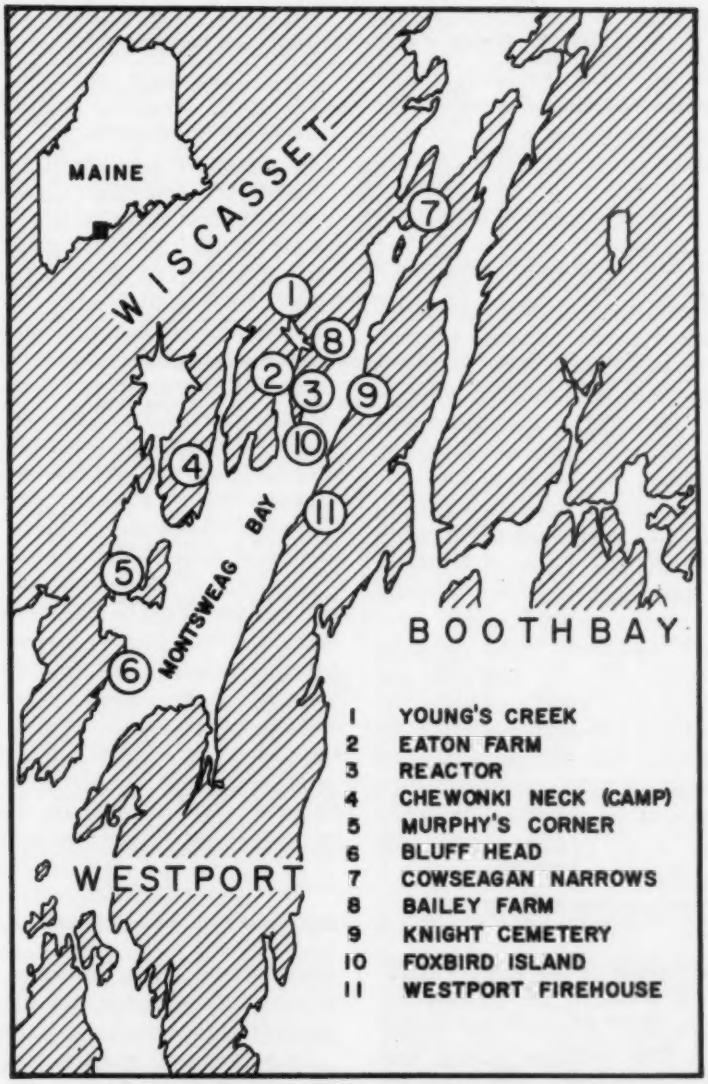

Figure 1. Region near Maine Yankee Atomic Power Plant, Wiscasset, Maine

Eaton Farm, Bailey Farm, Young's Creek, Knight Cemetery, Westport Firehouse, Chewonki Neck (camp), Cowseagan Narrows, and Bluff Head. Sediment samples were collected at Foxbird Island on the outfall side of the causeway and at Murphy's Corner. Soil samples were collected using a disc-cutter sampler which would cut a cylindrical soil sample, 15 cm in diameter by 15 cm deep. Four soil samples this size, each centered at the corner of a square grid, 25 cm on an edge, were collected at each of the nine sites. The four soil samples including surface vegetation were mixed and the root mats pulverized. The sample was then screened and all material smaller than 5 mm retained. The sample was then dried at 150°C. for 24 hours. In the case of the sediment samples, the top 2 centimeters were collected. These samples were screened and dried in an identical manner. In

Table 1. Results of soil and sediment field measurements

Location and distance from reactor site	Date measured (1972)	Type	Thorium-232 series (pCi/kg wet weight)	Uranium-238 series (pCi/kg wet weight)	Potassium-40 (pCi/kg wet weight)	Cesium-137 (pCi/kg wet weight)
Foxbird Island, 0.1 km S	6/29	soil	1 600 ±100	600 ±100	14 000 ±3 500	5 900 ± 800
Eaton Farm, 0.4 km W	6/26	soil	2 400 ±100	700 ±100	21 000 ±5 000	5 600 ±2 700
Bailey Farm, 0.8 km NE	6/27	soil	2 000 ±100	800 ±200	16 000 ±6 000	3 300 ± 600
Young's Creek, 1.0 km N	6/27	soil	1 600 ±400	600 ±200	14 000 ±9 000	4 000 ±1 400
Knight Cemetery, 1.1 km E	6/27	soil	3 100 ±300	600 ±200	20 000 ±6 000	9 500 ±1 600
Westport Firehouse, 1.8 km S	6/27	soil	1 500 ±100	500 ±100	14 000 ±3 000	7 600 ±2 000
Chewonki Neck (camp), 1.9 km SW	6/26	soil	1 900 ±100	500 ±150	20 000 ±4 000	5 000 ±1 100
Cowseagon Narrows, 3.2 km NE	6/27	soil	1 700 ±100	500 ±100	15 000 ±3 000	5 400 ± 800
Bluff Head, 4.0 km SSW	6/28	soil	2 000 ±100	800 ±300	16 000 ±5 000	6 300 ±1 400
Murphy's Corner, 2.8 km SW	7/3	sediment	1 400 ±100	400 ±200	9 000 ±4 000	7 000 ±1 900

Table 2. Results of soil and sediment laboratory measurements[a]

Location	Date collected (1972)	Date counted (1972)	Type	Thorium-232 series				Uranium-238 series			Other natural radioactivity	Man-made	Comments unidentified peaks[b]
				^{228}Ac (pCi/kg)	^{212}Pb (pCi/kg)	^{212}Bi (pCi/kg)	^{208}Tl (pCi/kg)	^{226}Ra (pCi/kg)	^{214}Pb (pCi/kg)	^{214}Bi (pCi/kg)	^{40}K (pCi/kg)	^{137}Cs (pCi/kg)	(MeV)
Foxbird Island	6/29	7/20	Soil	1 200 ±100	960 ±100	<50	950 ±230	1 600 ±800	780 ±290	700 ±90	14 000 ±1 000	940 ±85	0.077 1.234
Eaton Farm	6/12	7/17	Soil	340 ±120	1 300 ±60	400 ±400	680 ±170	2 400 ±50	1 000 ±80	630 ±70	14 900 ±400	870 ±45	.077, .210 .794
Bailey Farm	6/12	7/12	Soil	1 240 ±300	1 430 ±130	<50	1 200 ±400	<20	780 ±150	810 ±150	14 600 ±1 300	1 670 ±110	.015, 1.077 .090
Young's Creek	6/12	7/14	Tidal marsh soil	880 ±250	<20	900 ±800	1 040 ±320	3 480 ±1 110	1 210 ±120	1 075 ±120	18 200 ±400	800 ±80	.077, .090
Knight Cemetery	6/12	6/26	Soil	1 210 ±200	1 360 ±160	<50	2 150 ±550	<20	970 ±270	700 ±80	11 200 ±1 200	4 960 ±110	.077, .088
Westport Firehouse	6/12	6/21	Soil	1 000 ±350	900 ±100	1 300 ±700	2 000 ±340	<20	840 ±140	920 ±120	11 800 ±900	1 110 ±85	.077
Chewonki Neck (camp)	6/12	7/20	Soil	1 100 ±250	780 ±130	<50	1 660 ±500	<20	825 ±250	1 370 ±300	13 200 ±1 200	3 340 ±130	.077, .088
Cowseagan Narrows	6/13	7/24	Soil	300 ±300	1 050 ±140	<50	3 000 ±200	<20	1 140 ±200	730 ±180	13 400 ±1 250	2 620 ±130	.077, .089 1.047
Bluff Head	6/12	6/22	Soil	660 ±300	1 070 ±140	<50	2 080 ±500	<20	1 150 ±200	1 100 ±180	11 300 ±1 240	2 030 ±110	.077, .087
Foxbird Island	6/29	7/28	Tidal marsh sediment	250 ±130	1 000 ±500	1 300 ±370	780 ±320	3 190 ±540	600 ±100	500 ±180	15 000 ±350	350 ±32	.077, .089 .094
Murphy's Corner	7/3	7/27	Tidal flat sediment	1 660 ±280	950 ±120	700 ±700	70 ±150	5 390 ±900	710 ±110	740 ±120	15 200 ±1 200	450 ±80	.077, .135 .192

[a] All measurements are based on dry weight.
[b] The unidentified peaks (0.077, 0.088, and 0.098 ± 0.002 MeV) are probably due to K-shell x rays from the lead shield and from the uranium and thorium series.

each case, a dry kilogram of the sample material was shipped to NERHL for gamma-ray analysis using a Ge(Li) detector and online computer analyzer. The detector system was calibrated using sodium-22, potassium-40, manganese-54, and selenium-75. Analysis was carried out by hand using the Compton continuum subtraction method (*8*). All samples were counted for a nominal 900 minutes (with a nominal 10 percent dead time) on a 2048 channel analyzer. The results of the analysis are listed in table 2.

The minimum detectable levels for actinium-228, lead-212, bismuth-212, thallium-208, radium-226, lead-214, bismuth-214, potassium-40, and cesium-137 are 45, 20, 50, 25, 20, 10, 10, 25, and 20 pCi/kg (dry weight), respectively. These values are based on both the resolution of the detector and a 2σ statistical confidence level for nominal environmental activities.

In general, all spectra contained potassium-40, contributions from both the thorium-232 series, and the uranium-238 series, and cesium-137. Furthermore, samples low in bismuth-212 are also low in radium-226. No members from the naturally occurring actinium series or neptunium series were observed.

Discussion of the soil and sediment results

Very good qualitative agreement between the soil and sediment field measurements can be seen by comparing table 1 and table 2. One would further expect that the results of the field measurements and the laboratory measure-

ments for potassium-40 and for cesium-137, respectively, would be in an order of magnitude agreement. This is also clear from these tables. However, because the field measurements and the laboratory measurements are quite different (instrumentation, calibration, and sample character) one would not expect exact numerical agreement. Still we can see that for relative rank by activity, both measurements indicate Eaton Farm and Bailey Farm to be higher in potassium-40 with Westport Firehouse being significantly lower, and both measurements indicate Knight Cemetery and Bluff Head to be higher in cesium-137 with Eaton Farm and Young's Creek lower. Because of the quite different calibration procedures used in these two measurements (see appendix A) one cannot directly compare the activities in the two naturally occurring decay series. Nevertheless, in the case of relative rank by activity, both measurements indicate (using actinium-228 as the indicator) higher activity at the Knight Cemetery and Bailey Farm sites for the thorium-232 series, with a significantly lower activity at Young's Creek. In the case of the uranium-238 series (using radium-226 as the indicator), the Eaton Farm and Bluff Head sites are significantly higher than Murphy's Corner. Considering the layering nature of the field samples and the homogeneous nature of the laboratory samples, one cannot expect a much higher correlation than observed.

Soil and sediment classification and analysis can be found in appendix B. Classification was carried out in the field by a soil specialist from the Plants and Soils Department of the University of Maine. The same department did the laboratory analyses for pH and the exchangeable components of phosphorus, potassium, calcium, and magnesium (acetic acid extraction method). Based on soil chemistry, the measurements verify the expectation that there is a fairly consistent relationship exists between the exchangeable component of potassium in the soil and the potassium-40 activity, the magnesium in the soil and the radium-226 activity, and the phosphorus in the soil and the bismuth-214 activity. Good agreement also exists between the potassium in the soil and the soil type and the cesium in the soil and the depth of the organic mat (layers 0_1 and 0_2, see appendix B). From this, one concludes that the soil chemistry is a main feature in determining the retention capabilities in these soils for the isotopes mentioned and that the organic layers may play a dominant role in the uptake and retention of cesium.

RADIONUCLIDES IN THE WATER

Water field measurements

Radionuclides in the water were measured at Foxbird Island, Young's Creek, Cowseagan Narrows, and Bluff Head (figure 1). The portable multichannel analyzer system and support equipment used for the soil field measurements was used for these water measurements. The only modification necessary was to float the shield-detector assembly in a canoe over the water being measured. At all times, a minimum depth of 1 meter was maintained below the detector during measurement. All water field measurements were taken on half memory (512 channels) for 4 000 seconds. At the end of two runs, the multichannel analyzer was returned to the Maine Yankee Environmental Studies Center at Bailey Point and the memory outputted into the teletype. The water field measurements were only qualitatively analyzed because for reasonable in-the-field counting times (on the order of an hour), the count rate was so low that the gamma-ray photopeaks for nominal environmental concentrations were substantially masked by the counting statistics. However, several general observations can be drawn from the field data. The major contributors to the spectra were potassium-40 and the daughters of radon-222. The potassium concentration is the same for Foxbird Island, Cowseagan Narrows, and Bluff Head and is indicative of the common salinity of these estuarine samples (it corresponds to about 10 dps/liter). The potassium-40 contribution to the Young's Creek spectrum is essentially zero, as expected. The bulk of the rest of the spectra is made up of the daughters of radon-222 with the exception of the Bluff Head sample, which contained very little radioactivity. In general, the water samples were a full order of magnitude less active than the soil field measurements.

Water laboratory measurements

Water samples for laboratory analysis were collected at seven sites (tables 3 and 4). Each water sample was separated into a dissolved component and an undissolved component. This separation was done by filtering the sample in the field at the time of collection. The water was filtered using a Millipore high pressure filtering unit (a nominal over pressure of dry nitrogen gas of 28 000 kg/m^2 (40 pounds per square inch) resulted in a filter time of about 5 minutes). A Millipore 90 mm filter holder was loaded with a Whatman No. 1 paper filter, a Millipore AP3207500 spacer, a Millipore SCWP09025 cellulose ester 8.0 μm filter, a Millipore AP3207500 spacer and a Millipore HAWPO9025 cellulose ester 0.45 μm filter for each water sample. Using the above arrangement, 4 liters of water from each site were filtered. The filtered water (dissolved component) was placed in a 1-gallon plastic shipping container to which 40 ml of nitric acid were added to stabilize the sample. Prior to acidification, a 50 ml sample from each site was placed in a plastic bottle for tritium analysis, The dissolved component (1 gallon sample) and the undissolved component (filter) were sent to NERHL for gamma-ray analysis.

The dissolved component was gamma analyzed using a 12.5 cm by 12.5 cm NaI(Tl) de-

Table 3. Laboratory gamma analysis of the dissolved component of water samples[a]

Location and distance from reactor site	Type	Date collected (1972)	Date counted (1972)	Potassium[b] (g/liter $\pm 2\sigma$)	Cesium-137 (pCi/liter $\pm 2\sigma$)	Radon-222 (pCi/liter $\pm 2\sigma$)
Foxbird Island 0.1 km S	Estuarine	6/13	6/22	0.18±0.06	<2.0	<4.0
Eaton Farm 0.4 km W	Well	6/13	6/22	<.10	<2.0	<4.0
Bailey Farm 0.8 km NE	Well	6/13	6/22	<.10	<2.0	81.0±13.0
		6/13	6/29	<.10	<2.0	<4.0
Young's Creek 1.0 km N	Surface	6/13	6/22	<.10	<2.0	<4.0
		6/13	6/22	<.10	<2.0	98.2±19.2
Chewonki Neck (camp) 1.9 km SW	Well	6/13	6/27	<.10	<2.0	<4.0
Cowseagan Narrows 3.2 km NE	Estuarine	6/13	6/22	.19± .06	<2.0	<4.0
Bluff Head, 4.0 km SSW	Estuarine	6/13	6/22	.16± .06	<2.0	<4.0

[a] All samples were counted for 50 minutes in a 3.5 liter Marinelli beaker geometry.
[b] Determined by measuring potassium-40.

Table 4. Laboratory analysis of the undissolved components of water samples

Location and distance from reactor site	Date collected (1972)	Date counted (1972)	Type of sample	Sample mass (grams)	Thorium-232 series			Uranium-238 series		Other natural radioactivity	Comments
					^{228}Ac (pCi/liter)	^{212}Bi (pCi/liter)	^{208}Tl (pCi/liter)	^{214}Pb (pCi/liter)	^{214}Bi (pCi/liter)	^{40}K (pCi/liter)	Unidentified peaks[a] (MeV)
Foxbird Island 0.1 km S	6/13	7/31	Estuarine	0.131 ±.005	<45	100±20	<25	<10	<10	<25	0.077
Eaton Farm 0.4 km W	6/13	8/11	Well	.00 ±.005	<45	<10	<25	30 ±20	<10	<25	.077 .087
Bailey Farm 0.8 km NE	6/13	8/9	Well	.007 ±.005	200 ±45	<10	<25	<10	<10	<25	.077, .090 .098
Young's Creek 1.0 km N	6/13	8/10	Surface	.045 ±.005	<45	<10	<25	<10	<10	<25	.077
Chewonki Neck (camp) 1.9 km SW	6/13	8/3	Well	.002 ±.005	<45	<10	<25	<10	<10	<25	.077
Cowseagan Narrows 3.2 km NE	6/13	8/2	Estuarine	.114 ±.005	<45	<10	30 ±25	<10	<10	<25	.077
Bluff Head 4.0 km SSW	6/13	8/7	Estuarine	.163 ±.005	<45	<10	70 ±25	<10	<10	<25	.077

[a] The unidentified peaks (0.077, 0.088, and 0.098 ± 0.002 MeV) are probably due to K shell x rays from the lead shell and from the uranium and thorium series.

two groups (Bailey Farm and Eaton Farm on 6/30/72 and Chewonki Neck (camp) and Westport Firehouse on 7/3/72) separated by 72 hours and an intervening cold-front rain shower, the data are essentially identical. The exhalation rate of radon from the soils in this region is not documented, the attachment of decay products on natural aerosols is a function of the natural aerosol size distribution and therefore, this size distribution was not measured, and the filter efficiency of the fiberglass filters as a function of the aerosol size distribution is not known.

Air particulate laboratory measurements

Air particulates for laboratory analysis of radionuclides were collected at three sites (Eaton Farm, Bailey Farm, and Westport Firehouse). A Millipore pump type-xx600000 was used to pull air through a 47 mm diameter Millipore absolute aerosol 0.8 μm filter, type AAWP04700. The throughput of this system was metered for all runs with a calibrated gas volume flow meter, American Meter Company Model 10-300-PR1264. This meter was capable of reading up to 99 999.9 liters. The meter, pump, and filter holder were housed in an instrument box with a rubber hose from the filter holder to the outside. A nominal sampling time was 50 hours with a nominal sampling volume being on the order of 100 000 liters. The filters were weighed before and after collection. They were packaged carefully in separate plastic boxes and sent to the Northeastern Radiological Health Laboratory, Winchester, Mass. for gamma-ray analysis. Each sample was prepared for analysis by digestion of the filter and contents in hydrofluoric acid. Water was then added to make the total volume of the prepared sample 200 milliliters. The samples were counted using the same Ge(Li) detector system used for the laboratory soil and sediment measurements, and using a 200 milliliter geometry. The amount of particulate collected on each filter was nominally a few milligrams. The Eaton Farm filter was counted for 3840 minutes, and the Bailey Farm and Westport Firehouse filters were counted for 900 minutes each. Full spectral analysis of all three samples indicated no peaks statistically above background levels. Background peaks were observed at 0.077 MeV, 0.094 MeV, 0.351 MeV (lead-214), 0.510 MeV (thallium-208), 0.608 MeV (bismuth-214), 0.910 MeV (actinium-228), and 1.459 MeV (potassium-40). This would indicate that the activities for these isotopes (for 100 000 liters of air) are below their respective minimum detectable levels (15 pCi for lead-214, 85 pCi for thallium-208, 15 pCi for bismuth-214, 100 pCi for actinium-228, and 100 pCi for potassium-40).

Discussion of the air particulate results

For the standard measurements employed in this section and for the nominal count times and collection techniques, the bulk of the activity is attributed to the daughters of radon-222. Careful analysis of the gamma-ray peaks for lead-212 (0.239 MeV and 0.300 MeV) and lead-214 (0.295 MeV, 0.242 MeV and 0.352 MeV), daughters of radon-220 and radon-222, respectively, indicates the presence of radon-220. The relative abundance of radon-220 to radon-222 shows a fairly good correlation with the ratio of the activity in the thorium-232 series to the activity in the uranium-238 series as indicated by the field measurements of soil. This ratio was larger for Westport Firehouse and significantly lower for Bailey Farm (the Westport Firehouse site showed evidence of radon-220).

The laboratory air particulate measurements were analyzed for the uranium-238 series, the thorium-232 series, cesium-137, potassium-40, zirconium-niobium-95 and manganese-54. None of these isotopes was found at levels above its respective minimum detectable amount. Apparently, for low efficiency detectors like Ge(Li) to yield statistically meaningful data for air particulate measurements, larger particulate mass must be accumulated. Using the minimum detectable levels for the laboratory soil measurements, one must scale the air particulate data by at least a factor of 10 000. This would require the filtering of 10^6 liters of air having the relatively low particulate content found in this study in order to bring the activities of the various isotopes above their respective minimum detectable levels.

tector and 3.5 liter Marinelli beaker geometry in a safe-type shield. The output from the multichannel analyzer was computer processed and the results of this analysis are presented in table 3.

The minimum detectable levels for potassium (potassium-40), cesium-137, and radon-222 are calculated to be 0.10 g/liter, 2.0 pCi/liter, and 4.0 pCi/liter, respectively. These values are based on both the resolution of the detector and a 2σ statistical confidence level for nominal environmental activities.

The filters used for the undissolved component were weighed before use. After filtering, they were dried and reweighed to determine the amount of undissolved material that was deposited on them. The filters were sent to NERHL for gamma-ray analysis. Acid was used to dissolve the three filters from each sample, and water was added to bring the total volume to 200 milliliters. Each sample was counted for 900 minutes. The results of the gamma-ray analysis for the undissolved component are listed in table 4.

The minimum detectable levels for lead-214, thallium-208, bismuth-214, bismuth-212, potassium-40, and actinium-228 are 10, 25, 10, 10, 25, and 45 pCi/liter of water, respectively. These values are based on both the resolution of the detector and a 2σ statistical confidence level for the background of the counting system used. We can see from table 4 that for the size samples used, the activities are comparable to the minimum detectable levels. For an environment as uncontaminated as the one involved in this study and for water sources as clean, it would be advisable to filter perhaps 10 to 50 times as much water in order to get the gross activity higher. Because of the low activities involved, one can reach no specific conclusions concerning the undissolved component of the water.

Discussion of the water results

Several general observations can be made from the data in tables 3 and 4. The well water in this region contains considerable dissolved radon-222. This is due primarily to leaching from uranium oxide in the pegmatite deposits in this area. The estuarine waters contain, of course, potassium-40 in the dissolved form, however they also contain measurable amounts of thallium-208 in the undissolved form. Measurable amounts of bismuth-212 were found in the estuarine water off Foxbird Island and measurable amount of actinium-228 was found in the Bailey Farm well water. In general, the well waters have very low activity, especially that at the Eaton Farm site.

RADIONUCLIDES IN THE AIR PARTICULATES

Air particulate field measurements

Radionuclides in air particulates were measured at four sites, Eaton Farm, Bailey Farm, Westport Firehouse, and Chewonki Neck (camp). A staplex large volume air sampler was used in conjunction with a 20.5 cm ($8\frac{1}{16}$ inch) by 25.4 cm (10 inch) filter holder. Nuclear Associates, Inc. fiberglass filters number 08-780 were used. The air sampler was operated for 60 minutes at a nominal throughput of 1.56 m^3/min. Thus 93.6 m^3 of air were filtered at each site. The filter was folded three times (8 layers) and placed on the circular surface of the NaI(Tl) detector assembly used for the soil and sediment field measurements. For the air particulate measurements, eight layers of fiberglass filter followed by a 3 cm lead shield replaced the soil sample. All air particulate field data were obtained as soon after collection as possible (normally within a few minutes) on half memory (512 channels) for 4000 seconds (the first 2000 seconds on the first 512 channels and the second 2000 seconds on the second 512 channels). The multichannel analyzer was outputted on the teletype. Qualitative analysis shows that the bulk of the activity on the filters was due to the daughters of radon-222. The Westport Firehouse data show evidence of radon-220. This radon isotope from the thorium-232 series is just on the edge of being masked by statistical fluctuation. After a period of 24 hours, the activity on the filters is essentially background with a trace amount of potassium-40. Although the measurements were taken in

TRITIUM IN WATER, AIR MOISTURE, AND PRECIPITATION

Tritium in water

Tritium in water was measured in samples collected at seven locations, table 5. Each water sample was filtered as described earlier. A 50 milliliter sample from each site was sent to NERHL for tritium analysis using the direct-counting liquid scintillation method (*9, 10*). (The water samples were processed to remove impurities that cause quenching and a scintillation fluor was added.) The samples were counted in a low background chamber. The results of these measurements are presented in table 5.

Table 5. Tritium in water

Location and distance from reactor site	Date collected (1972)	Type	Measured results (nCi/liter ± 2σ)	Interpreted results [a]
Foxbird Island, 0.1 km S	6/13	Estuarine	0.39 ± 0.2	zero
Eaton Farm, 0.4 km W	6/13	Well	.40 ± .2	zero
Bailey Farm, 0.8 km NE	6/13	Well	.34 ± .2	zero
Young's Creek, 1.0 km N	6/13	Surface	.14 ± .2	zero
Chewonki Neck (camp) 1.9 km SW	6/13	Well	.30 ± .2	zero
Cowseagan Narrows, 3.2 km NE	6/13	Estuarine	.09 ± .2	zero
Bluff Head, 4.0 km SSW	6/13	Estuarine	.40 ± .2	zero

[a] The minimum detectable level for the analysis of tritium by the direct liquid scintillation counting method used in this study is 0.4 nCi/liter. All values equal to or less than 0.4 nCi/liter will be reported by convention as zero. Values greater than 0.4 nCi/liter but which round to this value will be reported as 0.4 nCi/liter.

Tritium in air moisture

Tritium in air moisture was measured in samples collected at Eaton Farm, Bailey Farm, and Westport Firehouse. Air moisture samples were collected by drawing air through a plastic cylinder (8-cm diameter by 24-cm long) containing a desiccant (*11*). The desiccant used was indicator type Dryrite. The cylinder of desiccant was weighed before the air was pulled through and weighed afterward to insure the collection of between 20 and 30 milliliters of air moisture. Nominal collection time was between 2 and 4 hours depending on the relative humidity. The desiccant cylinders were sealed and sent to NERHL for tritium analysis. The water was thermally driven from the desiccant in a closed system. The samples were processed for tritium analysis in the usual way. The results of these measurements are listed in table 6.

Table 6. Tritium in air moisture

Location and distance from reactor site	Date collected (1972)	Quantity measured (ml)	Measured results (nCi/liter ±2σ)	Interpreted results (nCi/liter) [a]
Eaton Farm, 0.4 km W	6/29	33.7	0.60 ± 0.2	0.6
Bailey Farm, 0.8 km NE	6/15	33.1	19.1 ± .2	19.1
Westport Firehouse, 1.8 km S	6/27	33.4	.60 ± .2	.6

[a] The minimum detectable level for the analysis of tritium by the direct liquid scintillation counting method used in this study is 0.4 nCi/liter. All values equal to or less than 0.4 nCi/liter will be reported by convention as zero. Values greater than 0.4 nCi/liter but which round to this value will be reported as 0.4 nCi/liter.

Tritium in precipitation

Tritium in precipitation was measured in snow samples collected at Knight Cemetery and Westport Firehouse on March 11, 1972 and rain samples collected at Eaton Farm and Bailey Farm on June 30, 1972. These samples were filtered in the same manner used for the water samples. Fifty milliliter samples were sent to NERHL for tritium analysis using the liquid scintillation method. The results of the analysis are listed in table 7.

Table 7. Tritium in precipitation

Location and distance from reactor site	Date collected (1972)	Type	Measured results (nCi/liter ±2σ)	Interpreted results (nCi/liter) [a]
Eaton Farm, 0.4 km W	6/30	Rain	0.40 ± 0.2	zero
Bailey Farm, 0.8 km NE	6/30	Rain	1.10 ± .2	1.1
Knight Cemetery, 1.1 km E	3/11	Snow	.26 ± .2	zero
Westport Firehouse, 1.8 km S	3/11	Snow	.17 ± .2	zero

[a] The minimum detectable level for the analysis of tritium by the direct liquid scintillation counting method used in this study is 0.4 nCi/liter. All values equal to or less than 0.4 nCi/liter will be reported by convention as zero. Values greater than 0.4 nCi/liter but which round to this value will be reported as 0.4 nCi/liter.

Discussion of tritium measurements

Tritium has a half-life of 12.5 years. It is produced naturally by cosmic radiation and artificially by nuclear weapons and nuclear reactors. The nuclear weapons tests of the early fifties and subsequent tests have generated considerable amounts of tritium so that now most of the tritium found in the interchangeable environmental reservoirs is manmade tritium and

will remain so for quite some time, even without further testing (*12*). The purpose of the tritium measurements was to document typical values for the tritium levels in various environmental media prior to the operation of the Maine Yankee Atomic Power Plant. The major uptake of tritium by the environment and hence the impact, if any, on the environment is via tritiated water, therefore, the HTO component of the tritium inventory was measured. No effort was made to measure the variation in the preoperational tritium background because it was not possible to make a meaningful measurement of this variation in the 8 weeks of this study. However, some tritium background measurements have been made by Maine Yankee, and over a period of a few years, these data may be analyzed for trends and variations. To our knowledge, no measurements have been made (other than in this study) of tritium in the air moisture in this region. The authors feel that this is an unfortunate oversight, and in view of the dense sea fogs characteristic of the Maine Coast under certain meteorological conditions, some effort should be made in this respect. In general, the results of the tritium measurements in this study were as expected for environmental levels and in line with those made by Maine Yankee. The only exception to this was the rather large value found in the air moisture collected at Bailey Farm on 6/15/72 (table 6). This is a fairly high value for an environmental sample and cannot be explained at this time.

Conclusions

The field and laboratory soil and sediment measurements show good qualitative agreement in ranking the various sites by relative activity for the radionuclides detected. The character of the radioactivity at the eight soil sites is quite different from that of the two sediment sites and the tidal marsh soil site (tables 1 and 2). These latter three sites (Foxbird Island tidal marsh sediment, Murphy's Corner tidal flat sediment and Young's Creek tidal marsh soil) show a relatively high amount of radium-226 and a relatively low amount of cesium-137 as compared to the other eight sites. This is in agreement with the soil chemistry of these samples as indicated by the high amount of exchangeable magnesium in the tidal sample and the relative lack of an organic top layer structure as compared to the soils. The cesium-137 activity was observed to be high at Knight Cemetery, Chewonki Neck (camp), Cowseagan Narrows and Bluff Head sites. We associate this activity with the loose organic mat (O_2) and the decayed organic mat (O_1) characteristic of these sites.

The dominant activity in the dissolved component of the water samples was dissolved radon-222 in the well water at Bailey Farm and Chewonki Neck (camp) (table 3). Potassium-40 in dissolved form was measured in estuarine water at sites, Foxbird Island, Cowseagan Narrows, and Bluff Head. Measurable amounts of activity were found in the suspended solids components of the water samples (table 4): actinium-228 was found in the Bailey Farm well water, bismuth-212 at Foxbird Island, thallium-208 was found in the Bailey Farm well water, bismuth-212 at Foxbird Island, thallium-208 at Cowseagan Narrows and Bluff Head and lead-214 in the Eaton Farm well water. Cesium-137 activity was below the minimum detectable level in both the dissolved and suspended solid measurements.

Air particulate field measurements showed radon-222 daughter activity at all sites. These data also show evidence of radon-220 daughters at the Westport Firehouse site.

Measurements of tritium in well, surface, and estuarine water samples showed no activity above the minimum detectable level (0.40 nanocuries per liter). Measurable quantities of tritium were found in air moisture (table 6). An unusually large amount was measured for the air moisture at the Bailey Farm site on June 15, 1972. A measurable amount of tritium was found in a rain sample taken at this site.

All gamma-ray spectra measured by the Ge(Li) detector system were examined for statistically significant peaks corresponding to gamma-ray energies for barium-140, iron-55, molybdenum-99, cesium-134, zirconium-95, niobium-95, cobalt-58, manganese-54, rubidium-88, iron-59, and cobalt-60. The activity of all these radionuclides was below their respective minimum detectable levels.

APPENDIX A

Calibration method for the field measurements

The field measurements in this study were computer analyzed using a least squares method. The computer program employed was developed at the Oak Ridge National Laboratory and is a gamma-ray spectrum fitting program known as ALPHA-M. This program uses a library of standard gamma-ray spectra, taken with the same detector and shield geometry as was used for the sample spectra being analyzed. For these measurements, spectra for potassium-40, cesium-137, the thorium-232 series and the uranium-238 series were used. The top shielded 2π geometry was simulated by uniformily distributing a known amount of radionuclide in an adequately large cylindrical volume of washed quartz sand. The size of this cylinder was determined experimentally using the natural abundance of potassium-40 in potassium chloride. Potassium-40 was chosen because the gamma ray from this radionuclide falls at the energy for minimum absorption for sand (*13*). Thus, an adequately large volume (a volume for which the addition of further material does not increase the observed activity) as determined in this manner will be adequate for all other gamma-ray energies, both larger and smaller than that for potassium-40 (1.459 MeV). The volume used was 16.8 cm high by 105 cm in diameter (the mass of dry washed sand contained in this volume is 25.45 kilograms). In order to insure that the radionuclide was dispersed uniformly throughout the sand and in order to further simulate the absorption coefficient of soil, the cylinder of dry sand was saturated with 5 liters of a water solution of the radionuclide. The standard spectra were then measured using the same detector, shield, cable and multichannel analyzer that were used for the field measurements. The detector-shield assembly was placed on the cylinder of the water-saturated sand in the same manner as used for the field measurements. All spectra were corrected for background activity by using a sand-and-water-only sample.

Calculation of the activity of each standard was carried out knowing the amount of radionuclide dispersed in the cylindrical volume and its branching ratio. The potassium-40 standard was calculated based upon the natural abundance of potassium-40 in natural potassium. Potassium chloride was used as the host. The cesium-137 standard was calculated based upon the known activity of a sample of cesium-137 provided by the Analytical Quality Control Service of the Environmental Protection Agency. The thorium-232 series standard was calculated based upon a sample of thorium nitrate known to be in secular equilibrium. This sample was 25 years old or older and its spectrum was calibrated in the usual manner. The uranium-238 series standard was calculated based upon a sample of uranium ore. The spectrum of the uranium ore was calibrated in the usual manner.

This calibration method was designed to simulate the top shielded 2π geometry and to take into account the absorption of gamma rays in the soil. It does not take into account the variations in the soil due to layering. These variations are primarily variations in radionuclide composition from layer to layer, with gamma-ray absorption gradations usually being a secondary consideration.

APPENDIX B

Soil and sediment classification and analysis

The soil and sediment samples in this study were classified and analyzed in the following manner. A field study at all soil and sediment sites was conducted by a soil specialist from the Department of Plants and Soils at the University of Maine. The soils and sediments were classified according to soil series name and the layer structures were typed and measured to a depth of 1 meter or bedrock. The samples collected from these sites for the soil and sediment laboratory measurements were chemically analyzed by the Maine Soil Testing Service at the University of Maine. The acetic acid extraction method was used to measure the amount of exchangeable phosphorus, potassium, calcium, and magnesium in all samples. The pH of each sample also was measured. The results of this classification and analysis are reported in table B-1.

The layer types and depths are given for each sample in the last column of the table. The soil field samples were collected to this depth as recommended by the staff of the Northeastern Radiological Health Laboratory.

The soils at the sites, Eaton Farm, Bailey Farm and Chewonki Neck (camp) had been disturbed by plowing to a depth of approximately 15 cm. This shallow plowing (premechanical plowing) took place at least 50 years ago as evidenced by the size of the trees at these locations. All other sites showed layering by natural processes only.

Table B–1. Results of soil and sediment classification analysis

Location and distance from reactor site	Sample	Soil series name	pH	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Layer types and depths in top 15 cm (14)
Foxbird Island, 0.1 km S	Soil	Agawan on bedrock	4.15	5	25	250	5	O_2 0–2.5 cm, O_1 2.5–10 cm A_2 10 cm–17.5 cm
Eaton Farm, 0.4 km W	Soil	Buxton (disturbed)	4.37	25	75	250	25	A_p 0–12.5 cm A_p and rocks 12.5–25 cm
Bailey Farm, 0.8 km NE	Soil	Poor Buxton	4.70	25	50	250	5	A_p 0–20 cm
Young's Creek, 1.0 km N	Tidal marsh soil	Tidal marsh	4.45	25	50	375	25	O_1 0–2.5 cm, A_1 2.5–5 cm A_1 5–7.5 cm, A_2 7.5 cm–15 cm
Knight Cemetery, 1.1 km E	Soil	Hollis	3.80	5	25	250	25	O_2 0–2.5 cm, O_1 2.5–5 cm A_2 5–7.5 cm, A_1–B_{21}
Westport Firehouse, 1.8 km S	Soil	Hollis	4.30	5	25	250	5	O_1 0–2.5 cm, A_2 2.5–5 cm A_1–B_{21}
Chewonki Neck (camp), 1.9 km SW	Soil	Hinkley	4.10	50	25	250	5	O_2 0–5 cm, A_p 2.5–5 cm B_{21} 5–15 cm
Cowseagan Narrows, 3.2 km NE	Soil	Hartland	3.90	5	25	250	5	O_2 0–5 cm, O_1 5–10 cm A_2 10–12.5 cm, B_{21} 12.5–22.5 cm
Bluff Head, 4.0 km SSW	Soil	Hollis	3.95	5	25	250	5	O_2 0–0.5 cm, O_1 0.5–3 cm A_2 3–8 cm, B_{21} 8–18 cm
Foxbird Island, 0.1 km S	Tidal marsh sediment	Marine sediment	6.10	50	500	375	1 000	0–2 cm Medium silt to medium sand
Murphy's Corner, 2.8 km SW	Tidal flat sediment	Marine sediment	5.70	50	500	500	1 500	0–2 cm Fine silt to fine sand

APPENDIX C

Discussion of error analysis used in the Compton continuum subtraction method

The Compton continuum subtraction method was used for the quantitative analysis of all laboratory measurements employing the Ge(Li) detector system. The measurements involved were soil, sediment, undissolved solids in water and air particulates, as well as the counting efficiency of the detector itself and the measurement of the background for these laboratory measurements.

For the Compton continuum subtraction method, once the photopeak was located, the most reproducible procedure is to use the peak channel and an equal number of channels on either side of that channel. We chose to use the photopeak channel and five channels on each side. A line estimating the base of the photopeak under consideration is then constructed. There are two numbers involved in the analysis: the sum of the 11 channels encompassing the photopeak, and the sum of the 11 values making up the baseline. We now associate with each of these numbers an uncertainty. The statistical analysis of random variables tells us in this case that each individual value N has associated with it a probable absolute error equal to $\sqrt{N}$. Calling the number of counts in the 11 channels of the baseline B, the area of the photopeak will be P—B. The absolute error associated with this area will be $\sqrt{P} + \sqrt{B}$ since the absolute error in an addition or subtraction is equal to the sum of the absolute errors in the input quantities. We find reported in tables 1, 2, 4, and appendix D, values with errors. These values and errors are based upon the photopeak area and associated absolute error, that is $(P—B) \pm (\sqrt{P} + \sqrt{B})$.

When the photopeak area (P—B) is less than $\sqrt{P} + \sqrt{B}$ we say that the amount of the particular isotope involved is less than the minimum detectable level. The minimum detectable level for a particular isotope is based upon the absolute error $\sqrt{P} + \sqrt{B}$, the detector efficiency calibration, and the appropriate branching ratio for that radionuclide. There are of course complicating circumstances for which this straightforward procedure would have to be modified. These more complicated cases were handled on an individual basis. The most frequent complication confronted in this study was cases in which the branching ratio was known to less accuracy than the statistical limits placed on the photopeak area. The area in these cases, dominated by the branching ratio information, was calculated based on the relative error in the product of the numbers involved as well as the statistical limitations on these numbers.

APPENDIX D

Background spectra for Ge(Li) analysis

Because of the very low activity in the undissolved water component and air particulate samples analyzed by laboratory measurement, it was necessary to qualify the background spectrum of the Ge(Li) detector shield assembly employed. For this purpose, an empty 200 milliliter container was placed in the usual manner in the Ge(Li) system and a spectrum was recorded. The count time was 3 840 minutes, beginning 8/4/72. The resulting spectrum contained seven statistically significant peaks. Peaks one and two, at 0.077 MeV and 0.087 MeV, respectively, are unidentified. The third peak, at 0.510 MeV, corresponds to 790 ± 80 pCi of thallium-228; the fourth peak, at 0.609 MeV, and the seventh peak, at 1.763 MeV, correspond to 80 ± 15 pCi of bismuth-214; the fifth peak, at 1.459 MeV, corresponds to 900 ± 100 pCi of potassium-40; and the sixth peak, at 1.592 MeV, corresponds to 300 ± 100 pCi of actinium-228. All laboratory data reported in this study have been corrected for this background.

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SECTION I. MILK AND FOOD

Milk Surveillance, October 1973

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption readily can be obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks reporting presently in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radio-

Figure 1. Milk sampling networks in the Western Hemisphere

strontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, first it was necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Research and Developments conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been previously outlined (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 18 laboratories producing data for the network reported in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration		Number of laboratories in each category				Experimental 2σ error (pCi/liter)
		Acceptable[a]	Warning level[b]	Unacceptable[c]	Total	
Iodine-131	(96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
	(438 or 484 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137	(53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
	(295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89	(29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
	(197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90	(32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
	(150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and generally is increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below those practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error of precision expressed as pCi/liter or percent in a given concentration range also has been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the United States data on radioactivity in milk in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations

Table 2. Concentrations of radionuclides in milk for October 1973 and 12-month period, November 1972 through October 1973

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	NA	5	0	4
Alaska:	Palmer [c]	P	NA	4	0	1
Ariz:	Phoenix [c]	P	NA	0	0	0
Ark:	Little Rock [c]	P	NA	10	0	1
Calif:	Los Angeles [c]	P	NA	0	0	0
	Sacramento [c]	P	NA	1	0	0
	San Francisco [c]	P	NA	0	0	0
	Del Norte	P	4	10	0	7
	Fresno	P	0	1	0	2
	Humboldt	P	0	3	0	1
	Los Angeles	P	2	1	0	1
	Mendocino	P	2	2	0	3
	Sacramento	P	0	2	0	2
	San Diego	P	0	1	0	2
	Santa Clara	P	0	2	0	2
	Shasta	P	0	2	0	2
	Sonoma	P	0	2	0	3
Colo:	Denver [c]	P	NA	3	0	0
	East	R	NS	NA	NS	22
	Northeast	R	NS	NA	NS	0
	Northwest	R	NA	NA	[d] 0	2
	South Central	R	NS	NS	NS	NS
	Southeast	R	NA	NA	[d] 0	0
	Southwest	R	NS	NA	NS	2
	West	R	NA	NA	[d] 0	0
Conn:	Hartford [c]	P	NA	4	0	4
	Central	P	7	6	0	0
Del:	Wilmington [c]	P	NA	5	0	2
D.C:	Washington [c]	P	NA	3	0	1
Fla:	Tampa [c]	P	NA	4	23	28
	Central	R	9	5	25	30
	North	R	9	7	16	13
	Northeast	R	7	6	38	33
	Southeast	R	6	5	65	50
	Tampa Bay area	P	7	5	34	29
	West	R	8	8	0	8
Ga:	Atlanta [c]	P	NA	4	0	5
Hawaii:	Honolulu [c]	P	NA	1	0	0
Idaho:	Idaho Falls [c]	P	NA	3	0	0
Ill:	Chicago [c]	P	NA	5	0	2
Ind:	Indianapolis [c]	P	NA	4	0	3
	Central	P	4	6	0	7
	Northeast	P	5	6	10	9
	Northwest	P	7	7	10	8
	Southeast	P	6	6	10	6
	Southwest	P	6	7	10	9
Iowa:	Des Moines [c]	P	NA	4	0	0
	Des Moines	P	NA		NA	
	Iowa City	R	NA		NA	
	LeMars	R	NA		NA	
	Little Cedar	P	NA		NA	
Kans:	Wichita [c]	P	NA	5	0	0
	Coffeyville	P	6	7	10	7
	Dodge City	P	5	5	0	5
	Falls City, Nebr	R	NS	NS	NS	NS
	Hays	P	5	6	0	4
	Kansas City	P	4	5	10	7
	Topeka	P	8	7	0	5
	Wichita	P	6	6	0	6
Ky:	Louisville [c]	P	NA	5	11	2
La:	New Orleans [c]	P	NA	8	0	1
Maine:	Portland [c]	P	NA	5	11	17
Md:	Baltimore [c]	P	NA	6	0	3
Mass:	Boston [c]	P	NA	7	0	13
Mich:	Detroit [c]	P	NA	6	0	2
	Grand Rapids [c]	P	NA	7	0	1
	Bay City	P	NS	7	NS	0
	Charlevoix	P	9	7	0 (4)	2
	Detroit	P	12	6	0	0
	Grand Rapids	P	12	7	13	3
	Lansing	P	16	9	0	3
	Marquette	P	12 (2)	9	0 (3)	3
	Monroe	P	31	10	12	1
	South Haven	P	17	10	0 (4)	3
Minn:	Minneapolis [c]	P	NA	7	0	3
	Bemidji	P	6	7	11	13
	Duluth	P	18	16	16	18
	Fergus Falls	P	6	6	0	0
	Little Falls	P	19	18	24	28
	Mankato	P	6	5	16	0
	Marshall	P	NS	4	NS	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for October 1973 and 12-month period, November 1972 through October 1973

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
Minn:						
	Minneapolis	P	NA	9	0	0
	Rochester	P	NS	7	NS	0
Miss:	Jackson [c]	P	NA	8	11	7
Mo:	Kansas City [c]	P	NA	4	0	0
	St. Louis [c]	P	NA	7	0	1
Mont:	Helena [c]	P	NA	2	0	0
Nebr:	Omaha [c]	P	NA	3	0	0
Nev:	Las Vegas [c]	P	NA	4	0	0
N.H:	Manchester [c]	P	NA	8	12	8
N.J:	Trenton [c]	P	NA	5	0	3
N. Mex:	Albuquerque [c]	P	NA	0	0	0
N.Y:	Buffalo [c]	P	NA	4	0	3
	New York City [c]	P	NA	5	0	3
	Syracuse [c]	P	NA	6	0	1
	Albany	P	0 (2)	4	0 (5)	0
	Buffalo	P	5	5	22	0
	Massena	P	NA	5	0	0
	New York City	P	5	7	0	0
	Syracuse	P	NS	5	NS	0
N.C:	Charlotte [c]	P	NA	7	0	6
N. Dak:	Minot [c]	P	NA	7	0	0
Ohio:	Cincinnati [c]	P	NA	5	0	2
	Cleveland [c]	P	NA	6	0	2
Okla:	Oklahoma City [c]	P	NA	3	0	0
Oreg:	Portland [c]	P	NA	4	0	1
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	P	NA		NA	
Pa:	Philadelphia [c]	P	NA	5	0	2
	Pittsburgh [c]	P	NA	8	0	4
	Dauphin	P	5	4	0	0
	Erie	P	7	6	0	0
	Philadelphia	P	4	4	0	1
	Pittsburgh	P	7	6	0	0
R.I:	Providence [c]	P	NA	5	0	6
S.C:	Charleston [c]	P	NA	6	13	7
	Chapin	R	NS	8	NS	11
	Clemson	R	NS	7	NS	5
	Columbia	R	NS	8	NS	10
	Fairfield	R	NS	7	NS	13
	Hartsville-02	R	NS	7	NS	14
	Hartsville-03	R	NS	16	NS	15
	Lee County	R	NS	8	NS	17
	Oconee County	R	9	8	11	8
	Pickens	R	7	7	6	6
	Wiliston	R	7	7	19	15
	Winnsboro	R	NS	7	NS	16
S. Dak:	Rapid City [c]	P	NA	5	0	1
Tenn:	Chattanooga [c]	P	NA	6	0	3
	Knoxville [c]	P	NA	0	0	0
	Memphis [c]	P	NA	6	0	2
	Chattanooga	P	NA	7	0	4
	Clinton	R	NA	6	0 (2)	5
	Fayetteville	R	NA	7	0 (3)	4
	Kingston	R	NA	7	0 (3)	0
	Knoxville	P	NA	5	0	2
	Lawrenceburg	R	NS	6	NS	6
	Nashville	P	NS	5	NS	3
	Pulaski	R	NA	6	0 (2)	0
	Sequoyah	R	NS	8	NS	0
Tex:	Austin [c]	P	NA	0	0	0
	Dallas [c]	P	NA	3	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	P	NA		NA	
Utah:	Salt Lake City [c]	P	NA	2	0	1
Vt:	Burlington [c]	P	NA	4	0	6
Va:	Norfolk [c]	P	NA	6	0	2

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for October 1973 and 12-month period, November 1972 through October 1973—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
Wash:	Seattle [c]	P	NA	2	0	0
	Spokane [c]	P	NA	5	0	0
	Benton County	R	NS	1	NS	0
	Franklin County	R	0	1	0	0
	Longview	R	4	3	10	3
	Sandpoint, Idaho	R	4	5	0	0
	Skagit County	R	3	4	0	1
W. Va:	Charleston [c]	P	NA	6	0	3
Wisc:	Milwaukee [c]	P	NA	4	0	2
Wyo:	Laramie [c]	P	NA	1	0	1
CANADA:						
Alberta:	Calgary	P	NA		6	9
	Edmonton	P	NA		14	13
British Columbia:	Vancouver	P	NA		11	14
Manitoba:	Winnipeg	P	NA		4	10
New Brunswick:	Moncton	P	NA		12	9
Newfoundland:	St. John's	P	NA		13	16
Nova Scotia:	Halifax	P	NA		10	10
Ontario:	Ottawa	P	NA		3	6
	Sault Ste. Marie	P	NA		19	16
	Thunder Bay	P	NA		9	13
	Toronto	P	NA		4	7
	Windsor	P	NA		6	6
Quebec:	Montreal	P	NA		5	7
	Quebec	P	NA		10	14
Saskatchewan:	Regina	P	NA		4	3
	Saskatoon	P	NA		10	3
CENTRAL AND SOUTH AMERICA:						
Canal Zone:	Cristobal [c]	P	NS	0	NS	9
Chile:	Santiago	P	0	0	0	0
Colombia:	Bogota	P	0	1	0	0
Ecudor:	Guayaquil	P	0	1	0	0
Jamaica:	Kingston	P	NS	2	NS	23
Puerto Rico:	San Juan [c]	P	NA	2	0	2
Venezuela:	Caracas	P	0	1	0	2
PMN network average [e]				4	1	3

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a month period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting level for this network differs from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:
Cesium-137: Colorado—25 pCi/liter; Oregon—15 pCi/liter.

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].

NA, no analysis.
NS, no sample collected.

which are reported routinely in *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups,

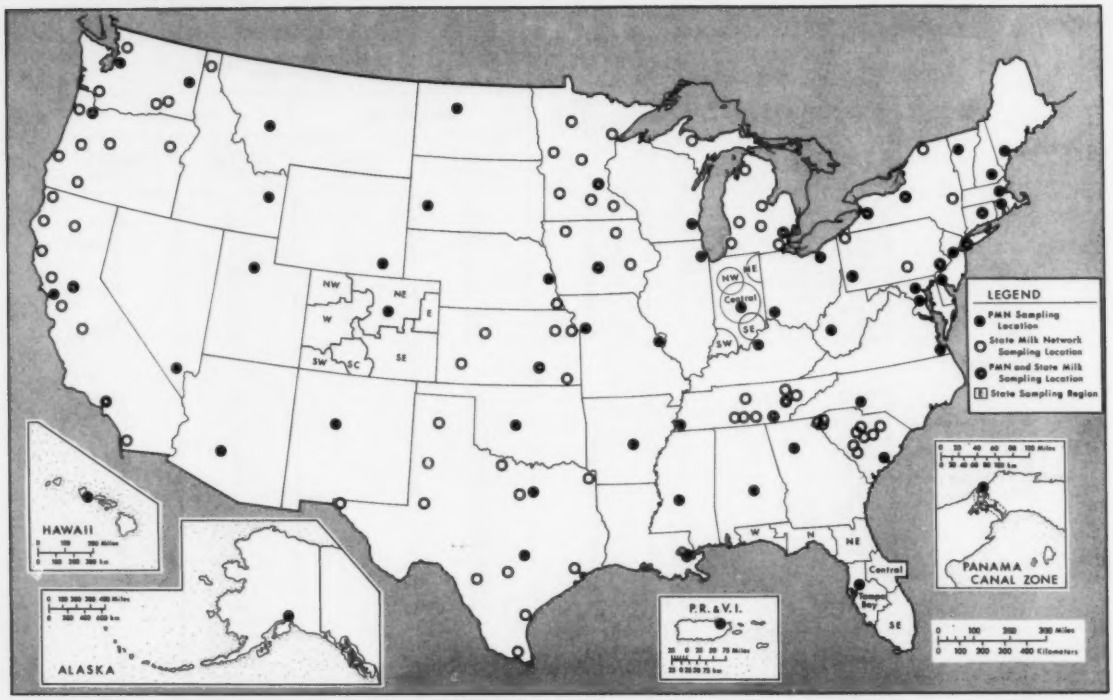

Figure 2. State and PMN sampling stations in the United States

averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for October 1973 and the 12-month period, November 1972 to October 1973. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at most of the stations for October 1973 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89 and iodine-131 were detected.

Table 3. Strontium-89 and iodine-131 in milk October 1973

Sampling location		Concentration (pCi/liter)	
		Strontium-89	Iodine-131
Kans:	Topeka (State)	5	
	Wichita (State)	7	
Minn:	Little Falls (State)		11
Colombia:	Bogota	7	

Strontium-90 monthly averages ranged from 0 to 31 pCi/liter in the United States for October 1973 and the highest 12-month average was 18 pCi/liter (Little Falls, Minn.) representing 9.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 65 pCi/liter in the United States for October 1973, and the highest 12-month average was 50 pCi/liter (Southeast Florida) representing 1.4 percent of the value derived from the recommendations given in the Federal Radiation Council report. Table 4 gives the strontium-89 and strontium-90 results of PMN milk samples composited by region.

Table 4. Strontium-89 and strontium-90 results of PMN milk samples composited by region

EPA region	States located in region	Strontium-90 concentration (pCi/liter)
I	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	*4
II	New Jersey, New York, Puerto Rico	4
III	Delaware, District of Columbia, Maryland Pennsylvania, Virginia, West Virginia	8
IV	Alabama, Canal Zone, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee	4
V	Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin	5
VI	Arkansas, Louisiana, New Mexico, Oklahoma, Texas	6
VII	Iowa, Kansas, Missouri, Nebraska	5
VIII	Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming	2
IX	Arizona, California, Hawaii, Nevada	0
X	Alaska, Idaho, Oregon, Washington	8

*Strontium-89 was 6 pCi/liter. All other strontium-89 results were less than the practical reporting level (5 pCi/liter).

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Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Laboratory Division
Connecticut Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Division of Radiological Health
South Carolina Department of Health and Environmental Control

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Unit
Health Services Division
Washington Department of
Social and Health Services

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Milk Surveillance Network, October 1973

National Environmental Research Center—Las Vegas, Environmental Protection Agency

The Milk Surveillance Network,[1] operated by the National Environmental Research Center —Las Vegas (NERC-LV) consists of 24 routine and 2 alternate sampling locations (figure 1) in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site.

In the event of a release of radioactivity from

[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

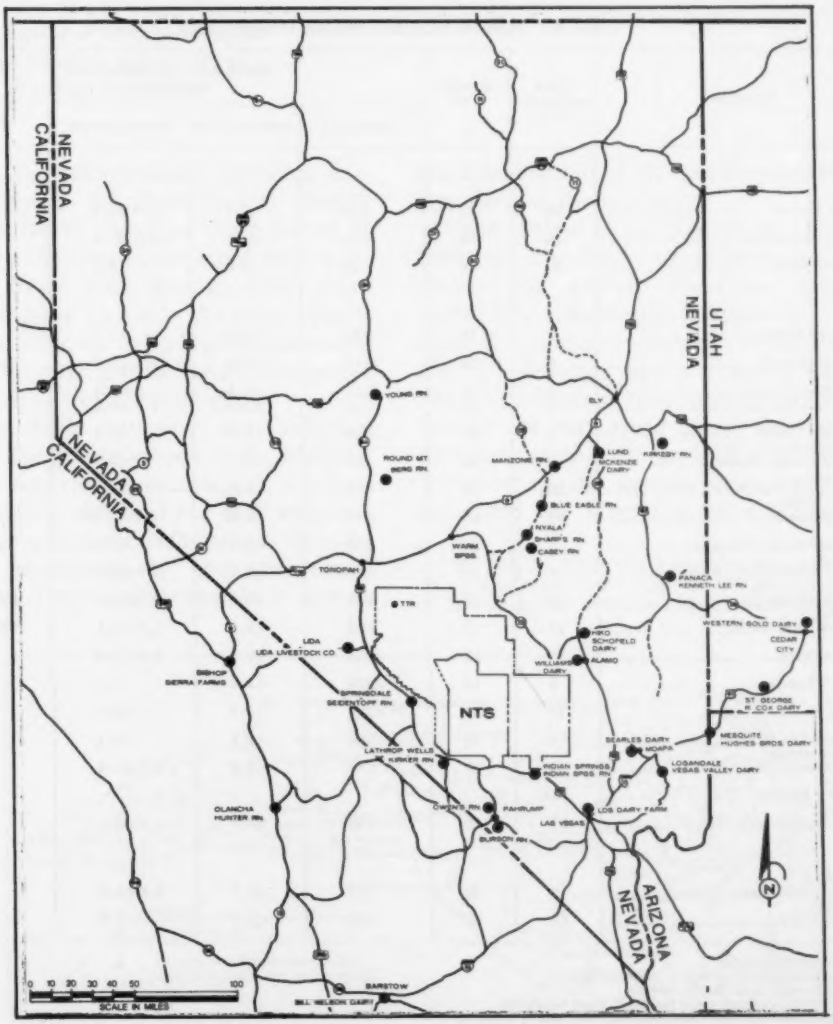

Figure 1. NERC-LV Milk Surveillance Network

the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations. Additional milk sampling networks are operated in support of AEC operations in areas other than the NTS when requested.

Results

During nuclear testing at the NTS in October 1961, the Milk Surveillance Network was established with routine samples collected monthly. This sampling frequency was continued until October 1, 1973, when the collection frequency was changed to quarterly. This change was implemented to economize on operations and yet maintain adequate sampling capability in case of a release of radioactivity from the NTS. The sampling and analytical procedures which have not been changed with this revision of the network, are included with the milk results reported in the July 1973 issue of *Radiation Data and Reports.*

The analytical results of all milk samples collected in October 1973 by NERC-LV are listed in table 1. With the exception of cesium-

Table 1. Milk surveillance results, October 1973

Location	Date collected (1973)	Sample type[a]	Radionuclide concentrations[b] (pCi/liter)			
			Cesium-137	Strontium-89	Strontium-90	Tritium
California:						
Bishop:						
Sierra Farms	24	11	<10	<2.0	1.9±1.2	NA
Hinkley:						
Bill Nelson Dairy	23	12	<10	<1.9	7.5±5.5	NA
Olancha:						
Hunter Ranch	24	13	<10	<1.8	<5.5	NA
Nevada:						
Alamo:						
Williams Dairy	1	12	<10	<2.0	<1.1	NA
Austin:						
Young's Ranch	8	13	<10	<2.0	2.5±1.4	630±250
Currant:						
Blue Eagle Ranch	9	13	<10	<2.0	2.3±1.2	NA
Manzonie Ranch	8	13	<10	<2.0	1.4±1.1	NA
Hiko:						
Schofield Dairy	1	12	[c] <100	<2.0	<1.1	<240
Indian Springs:						
Indian Springs Ranch	15	13	<10	<2.0	<1	NA
Las Vegas:						
LDS Dairy Farms	22	12	<10	<1.0	1.1± .80	<260
Lathrop Wells:						
Kirker Ranch	19	13	<10	<1.0	1.8± .90	NA
Lida:						
Lida Livestock Company	2	13	<10	<2.0	<1.2	NA
Logandale:						
Vegas Valley Dairy	16	12	<10	<2.0	2.5±1.2	NA
Lund:						
McKenzie Dairy	16	12	<10	<2.0	2.0±1.1	280±140
Mesquite:						
Hughes Bros. Dairy	16	12	<10	<2.0	1.3±1.1	300±240
Moapa:						
Searles Dairy	16	12	<10	<2.0	2.2±1.4	NA
Nyala:						
Sharp's Ranch	8	13	[c] <100	<1.0	<.9	<240
Pahrump:						
Owens Ranch	18	13	[c] <100	<2.0	1.7±1.0	NA
Panaca:						
Kenneth Lee Ranch	4	13	[c] <100	<2.0	<1.1	NA
Round Mountain:						
Berg Ranch	8	13	<10	<2.0	2.6±1.4	NA
Shoshone:						
Kirkeby Ranch	NS					
Springdale:						
Seidentopf Ranch	17	13	<10	<2.0	1.8±1.0	NA
Utah:						
Cedar City:						
Western Gold Dairy	17	12	<10	<2.0	2.0±1.3	NA
St. George:						
R. Cox Dairy	17	12	<10	<1.0	<.9	NA

[a] 11–Pasteurized milk.
12–Raw milk from Grade A producer(s).
13–Raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
[c] Small sample size increased minimum detectable activity.
NA, no analysis.
NS, no sample.

137 at levels near the minimum detectable concentration (MDC) of 10 pCi/liter, no gamma emitting fission products were identified by gamma spectrometry in any of the samples collected in October 1973. Levels of tritium near the MDC for this radionuclide (~ 200 pCi/liter) were also measured by liquid scintillation counting techniques. The highest concentration of tritium during October 1973 was 630 ± 250 pCi/liter.

Pasteurized Milk Sampling in North Carolina January 1967 Through August 1973

Division of Facility Services[1]
North Carolina Department of Human Resources

As part of its environmental radiation surveillance program, the Radiological Health Section of the North Carolina State Board of Health[1] began collecting pasteurized milk samples in 1964. From 1967 through 1972, there were seven sampling points in the State (figure 1). In January 1973, the Wilmington processing plant closed and milk processing for the area's dairies was transferred to Raleigh.

Pasteurized milk samples are collected monthly from the six milksheds in the State by county health department sanitarians. A representative sample is obtained for each milkshed by compositing milk from each dairy within the milkshed in proportion to each processing plant's volume. The 1 gallon sample is sent to the Department of Human Resources' Laboratory Section for analysis.

Upon arrival at the laboratory, the sample is transferred to a 3.5 liter polyethylene Marinelli beaker for gamma spectrum analysis for iodine-131, cesium-137, barium-140, and potassium-40. Gamma analysis utilizes a 4-inch NaI(Tl) detector and a Nuclear Data Model 130A 512-channel spectrometer. Gamma calculations are performed using the simultaneous equations method on an IBM-370 computer.

Following the gamma scan, the sample is processed for strontium-89 and strontium-90

[1] On July 1, 1973, the Radiation Protection Program was transferred from the North Carolina State Board of Health to the new Division of Facility Services.

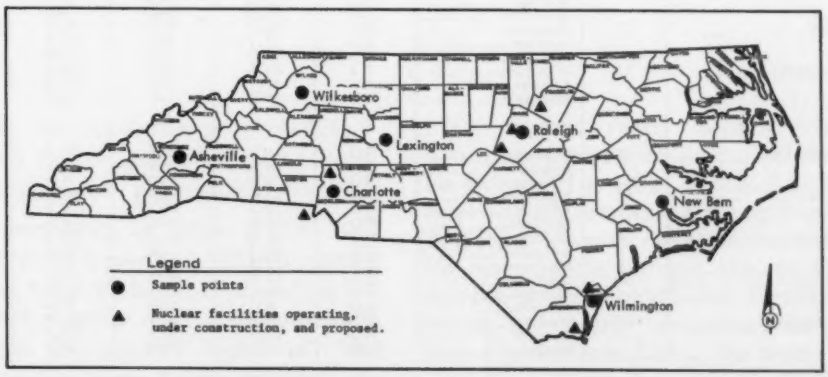

Figure 1. North Carolina milk sampling network

Table 1. Milk analysis results, North Carolina, 1967-1972

Year and location	Number of samples	Activity[a] (pCi/liter)	^{89}Sr	^{90}Sr[b]	^{131}I	^{137}Cs[c]	^{140}Ba
1967:							
Asheville	13	Maximum	ND	15.5	16.8	41.8	ND
		Average	ND	12.5	10.9	18.3	ND
		Minimum	ND	ND	ND	ND	ND
New Bern	13	Maximum	5.8	18.8	31.6	44.3	24.5
		Average	5.1	14.9	12.5	24.5	11.1
		Minimum	ND	13.4	ND	13.6	ND
Lexington	13	Maximum	5.3	23.1	16.9	32.0	ND
		Average	5.0	16.8	10.7	17.8	ND
		Minimum	ND	14.0	ND	ND	ND
Charlotte	22	Maximum	7.1	18.5	39.1	54.4	12.4
		Average	5.1	15.8	11.1	17.2	10.1
		Minimum	ND	11.3	ND	ND	ND
Wilmington	12	Maximum	7.2	18.3	ND	38.9	ND
		Average	5.2	15.4	ND	22.8	ND
		Minimum	ND	12.2	ND	11.4	ND
Raleigh	13	Maximum	ND	18.5	27.4	29.2	14.3
		Average	ND	14.1	14.7	17.8	10.4
		Minimum	ND	10.9	ND	ND	ND
Wilkesboro	13	Maximum	7.9	26.0	18.3	30.1	10.6
		Average	5.2	18.3	11.5	20.0	10.0
		Minimum	ND	14.2	ND	10.2	ND
1968:							
Asheville	10	Maximum	ND	18.9	47.6	32.8	17.8
		Average	ND	13.8	21.1	18.1	10.6
		Minimum	ND	ND	ND	ND	ND
New Bern	12	Maximum	ND	18.7	52.1	31.6	19.0
		Average	ND	15.2	20.9	21.5	10.8
		Minimum	ND	12.9	ND	13.0	ND
Lexington	8	Maximum	5.7	22.6	64.4	33.5	ND
		Average	5.1	17.2	25.4	19.7	ND
		Minimum	ND	14.0	ND	ND	ND
Charlotte	12	Maximum	ND	18.6	50.8	23.1	ND
		Average	ND	16.1	17.8	15.9	ND
		Minimum	ND	14.6	ND	11.3	ND
Wilmington	10	Maximum	5.2	16.1	43.7	37.9	ND
		Average	5.0	14.1	20.9	26.2	ND
		Minimum	ND	11.9	ND	15.5	ND
Raleigh	12	Maximum	ND	14.9	47.5	35.9	ND
		Average	ND	13.4	16.1	16.1	ND
		Minimum	ND	10.6	ND	ND	ND
Wilkesboro	12	Maximum	ND	24.7	50.7	31.5	ND
		Average	ND	18.9	26.2	19.8	ND
		Minimum	ND	14.5	ND	ND	ND
1969:							
Asheville	10	Maximum	5.9	14.9	34.5	21.4	37.7
		Average	5.1	11.3	12.0	15.6	12.3
		Minimum	ND	ND	ND	ND	ND
New Bern	12	Maximum	7.6	15.5	ND	36.0	ND
		Average	5.2	11.9	ND	18.6	ND
		Minimum	ND	ND	ND	ND	ND
Lexington	9	Maximum	13.8	18.7	30.2	40.3	ND
		Average	6.2	13.2	12.2	16.7	ND
		Minimum	ND	ND	ND	ND	ND
Charlotte	12	Maximum	9.0	21.2	ND	18.3	ND
		Average	5.3	14.3	ND	14.6	ND
		Minimum	ND	ND	ND	ND	ND
Wilmington	12	Maximum	ND	15.0	ND	39.7	ND
		Average	ND	12.0	ND	23.8	ND
		Minimum	ND	ND	ND	ND	ND
Raleigh	12	Maximum	ND	14.7	ND	20.7	ND
		Average	ND	11.3	ND	13.3	ND
		Minimum	ND	ND	ND	ND	ND
Wilkesboro	12	Maximum	5.2	21.9	ND	24.4	ND
		Average	5.0	16.7	ND	15.8	ND
		Minimum	ND	ND	ND	ND	ND
1970:							
Asheville	12	Maximum	ND	ND	32.6	20.9	15.4
		Average	ND	ND	13.9	14.9	10.7
		Minimum	ND	ND	ND	ND	ND
New Bern	12	Maximum	ND	11.5	14.9	29.0	ND
		Average	ND	10.2	10.4	16.2	ND
		Minimum	ND	ND	ND	ND	ND
Lexington	12	Maximum	ND	12.6	49.6	24.0	18.9
		Average	ND	10.6	15.9	13.5	11.3
		Minimum	ND	ND	ND	ND	ND
Charlotte	12	Maximum	5.2	13.2	49.8	27.3	21.6
		Average	5.0	10.7	12.1	13.8	10.8
		Minimum	ND	ND	ND	ND	ND
Wilmington	10	Maximum	ND	10.8	15.1	23.9	ND
		Average	ND	10.1	10.5	18.0	ND
		Minimum	ND	ND	ND	11.2	ND

See footnotes at end of table.

Table 1. Milk analysis results, North Carolina, 1967-1972—continued

Year and location	Number of sample	Activity[a] (pCi/liter)	^{89}Sr	^{90}Sr[b]	^{131}I	^{137}Cs[c]	^{140}Ba
Raleigh	12	Maximum	ND	10.8	19.5	20.6	12.9
		Average	ND	10.1	10.8	13.9	10.2
		Minimum	ND	ND	ND	ND	ND
Wilkesboro	11	Maximum	5.6	15.9	19.8	23.0	19.8
		Average	5.1	11.4	11.9	12.7	10.8
		Minimum	ND	ND	ND	ND	ND
1971:							
Asheville	14	Maximum	5.5	11.0	49.7	37.7	ND
		Average	5.0	10.9	16.9	17.5	ND
		Minimum	ND	ND	ND	ND	ND
New Bern	13	Maximum	6.8	14.9	30.3	26.7	ND
		Average	5.3	10.7	13.4	17.4	ND
		Minimum	ND	ND	ND	ND	ND
Lexington	10	Maximum	5.9	14.9	25.7	24.2	16.9
		Average	5.1	10.5	13.9	16.8	11.8
		Minimum	ND	ND	ND	ND	ND
Charlotte	12	Maximum	8.5	14.9	25.9	25.9	14.3
		Average	5.3	11.2	14.0	17.4	10.4
		Minimum	ND	ND	ND	ND	ND
Wilmington	8	Maximum	5.2	13.9	16.5	27.0	ND
		Average	5.0	10.6	12.0	21.7	ND
		Minimum	ND	ND	ND	ND	ND
Raleigh	15	Maximum	6.0	12.6	16.1	21.0	ND
		Average	5.1	10.3	10.7	15.2	ND
		Minimum	ND	ND	ND	ND	ND
Wilkesboro	10	Maximum	9.5	12.4	23.9	17.8	16.4
		Average	5.5	10.5	12.8	16.3	10.6
		Minimum	ND	ND	ND	ND	ND
1972:							
Asheville	14	Maximum	ND	ND	36.2	16.9	16.3
		Average	ND	ND	15.1	8.8	10.5
		Minimum	ND	ND	ND	ND	ND
New Bern	13	Maximum	ND	ND	30.4	18.7	ND
		Average	ND	ND	10.8	11.5	ND
		Minimum	ND	ND	ND	ND	ND
Lexington	15	Maximum	ND	11.3	40.2	16.2	ND
		Average	ND	10.1	10.2	8.6	ND
		Minimum	ND	ND	ND	ND	ND
Charlotte	10	Maximum	ND	11.1	49.2	22.9	18.3
		Average	ND	10.1	16.6	9.0	11.0
		Minimum	ND	ND	ND	ND	ND
Wilmington	11	Maximum	ND	11.2	27.4	24.3	ND
		Average	ND	10.1	14.1	14.0	ND
		Minimum	ND	ND	ND	ND	ND
Raleigh	16	Maximum	ND	ND	23.3	20.2	ND
		Average	ND	ND	12.3	9.4	ND
		Minimum	ND	ND	ND	ND	ND
Wilkesboro	14	Maximum	ND	12.0	45.8	24.0	17.8
		Average	ND	10.3	18.6	12.2	11.1
		Minimum	ND	ND	ND	ND	ND

[a] Minimum detectable activities are: strontium–89, 5 pCi/liter; cesium–137, 11.2 pCi/liter; all other listed, 10 pCi/liter.
[b] A value of 10.0 pCi/liter is used for averaging when the level of activity is less than the minimum detectable activity (MDA) except when all samples are below the MDA.
[c] Gamma spectra data printout lists concentrations even when below the MDA. These data are used to compute averages for cesium–137.
ND, nondetectable, below minimum detectable activity.

analysis using the ion-exchange procedure—TBP extraction method and counted on a Beckman low-beta II gas-flow proportional counter.

Data are presented in table 1 for 1967 through 1972. Table 2 provides 1973 strontium-90 results and table 3 shows 1973 cesium-137 and barium-140 monthly results. Strontium-89, iodine-131 and the unlisted cesium-137 and barium-140 results were below practical reporting levels.

The highest yearly isotopic concentration during the report period occurred in 1968 when the iodine-131 average was 26.2 pCi/liter, representing 26.2 percent of the applicable Federal Radiation Council radiation protection guide. No other yearly isotopic average exceeded 10 percent of FRC guidelines. Strontium-90 and cesium-137 yearly concentrations have continued to decrease during the report period.

At the present time, the North Carolina environmental radiation surveillance program is

Table 2. Results of strontium-90 analysis of pasteurized milk samples, North Carolina, January-August 1973

Sampling location	Strontium-90 (pCi/liter)							
	January	February	March	April	May	June	July	August
Asheville	3.9	4.3	4.5	4.9	5.2	6.2	6.2	5.8
New Bern	6.7	4.8	8.2	6.2	7.0	5.5	6.5	6.4
Lexington	5.3	6.5	5.7	6.5	7.7	8.3	7.1	7.2
Charlotte	5.8	NS	7.1	6.9	6.1	6.0	NS	6.8
Raleigh	7.7	5.3	5.3	6.3	5.6	6.2	6.7	6.7
Wilkesboro	7.9	6.0	6.7	7.1	8.9	9.3	NS	9.0

NS, no sample.

Table 3. Results of cesium-137 and barium-140 analyses of pasteurized milk above practical reporting levels North Carolina, January-August 1973

Sampling location	Month (1973)	Cesium-137 (pCi/liter)	Barium-140 (pCi/liter)
Asheville	January	(a)	12.5
New Bern	August	(a)	24.5
Lexington	August	16.6	28.2
Charlotte	August	(a)	22.5
Wilkesboro	August	11.6	19.9

[a] Below 10 pCi/liter.

beginning to shift emphasis from background to nuclear facility oriented sampling. When the milk sampling network was established, there were no nuclear facilities operating in the State. There are now two operating, two under construction, and three announced nuclear facilities in North Carolina. The location of these facilities is given in figure 1.

As nuclear power plants become operational, the nuclear facility surveillance network will include raw milk sampling at appropriate points near each facility. These will be in addition to the pasteurized samples collected. The surveillance program will then be able to determine the effect of individual nuclear facilities as well as the overall impact of radioisotopes in milk on the citizens of North Carolina.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
Carbon-14 in Total Diet and Milk	1972–1973	November 1973
Institutional Diet	January–March 1973	November 1973
Strontium-90 in Tri-City Diets	1972	December 1973

Estimated Daily Intake of Radionuclides in California Diets July 1971-December 1972

Radiologic Health Section, California State Department of Health

Since January 1964, the Radiologic Health Section, California State Department of Health, has made estimates of radionuclide levels in the diets of Californians (*1*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest (figure 1).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as "reasonably representative" as any other. General hospitals exist in each of the 20 selected geographic areas and operate with trained dietitians. There is good reason to be-

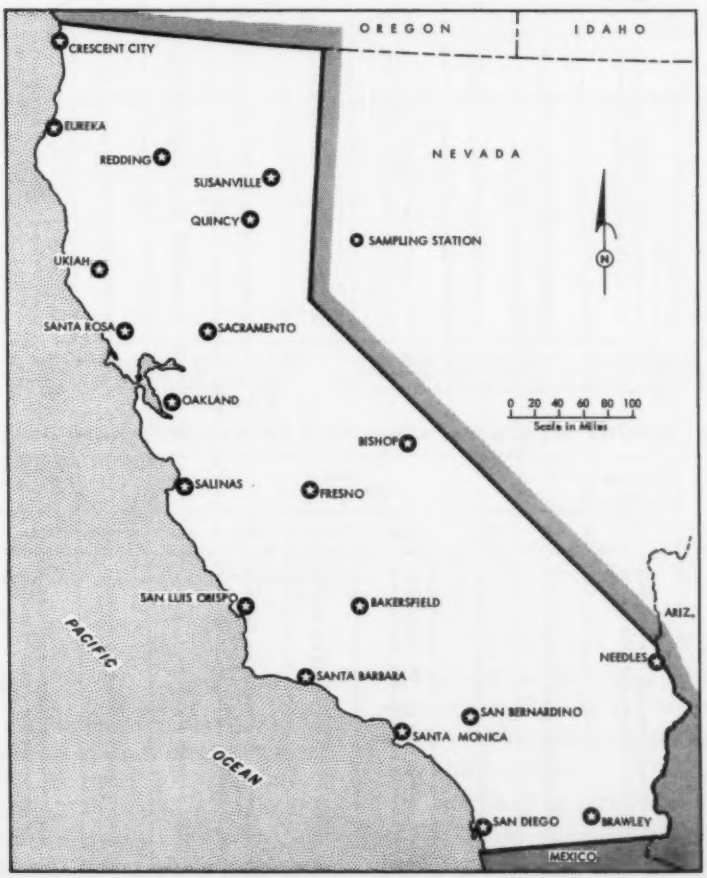

Figure 1. California diet sampling stations

lieve that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 3 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet), including liquids, for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory of the State Department of Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the laboratory, each sample is homogenized and analyzed for gamma-ray emitters, then dried and ashed prior to analysis for strontium-89, strontium-90, radium-226, stable calcium, strontium, and sodium.

Table 1. Estimated daily intakes of radionuclides in California diets,[a] July-September 1971

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}Ce$	K[c]	Na	Ca
Bakersfield	2.3	4	3	1.6	0	4	19	0	3.3	4.3	1.1
Bishop	1.9	5	4	1.9	1	2	17	0	2.7	2.8	1.0
Brawley	2.1	5	5	1.1	1	4	16	0	2.6	3.0	1.0
Crescent City	1.9	10	8	1.2	3	2	13	0	2.8	3.7	.7
Eureka	2.2	5	4	1.8	4	5	15	0	2.7	4.0	.8
Fresno	2.1	6	4	.4	9	0	6	0	3.1	3.4	1.0
Needles	2.2	3	4	1.3	0	6	14	0	2.3	2.5	.9
Oakland	2.1	3	5	1.5	4	5	17	0	2.8	3.5	.9
Quincy	2.1	14	4	2.5	1	7	14	0	2.4	3.0	.7
Redding	2.1	7	6	1.0	3	3	11	0	2.8	3.1	1.7
Sacramento	2.5	4	7	.4	11	0	0	0	3.1	4.7	1.0
Salinas	2.3	6	3	1.2	3	6	14	0	3.2	5.9	.7
San Bernardino	2.3	10	4	.6	14	0	0	0	3.4	4.5	1.2
San Diego	1.9	5	7	.8	7	10	23	6	2.9	2.9	1.5
San Luis Obispo	2.1	3	6	.8	0	2	21	0	3.1	3.5	1.1
Santa Barbara	2.0	5	7	1.2	11	0	1	0	2.6	3.7	1.4
Santa Monica	2.0	4	5	1.2	20	0	1	0	3.2	3.9	.9
Santa Rosa	1.7	5	5	1.8	11	0	3	0	2.3	4.0	.8
Susanville	2.2	5	3	.7	20	0	0	0	3.0	3.0	1.0
Ukiah	2.0	5	5	1.6	16	0	3	0	2.7	3.2	1.5

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet, including liquids.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis.

The practical reporting levels for these samples are: ^{89}Sr, 2.0 pCi/kg; ^{90}Sr, 1.0 pCi/kg; ^{226}Ra, 0.2 pCi/kg; ^{137}Cs, 7 pCi/kg; ^{95}Zr, 7 pCi/kg; ^{54}Mn, 7 pCi/kg; $^{141, 144}Ce$, 10 pCi/kg; and ^{40}K, 75 pCi/kg.

Table 2. Estimated daily intakes of radionuclides in California diets,[a] October-December 1971

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}Ce$	K[c]	Na	Ca
Bakersfield	2.3	8	6	1.8	13	0	6	0	3.4	5.2	1.1
Bishop	1.8	2	6	1.4	11	1	1	0	2.5	2.7	.9
Brawley	1.7	2	6	1.0	7	0	1	0	2.3	2.7	1.2
Crescent City	2.2	2	12	1.1	14	0	4	0	2.8	3.8	.9
Eureka	1.9	5	5	2.7	8	0	1	0	2.3	4.2	.7
Fresno	2.2	3	5	1.1	9	0	1	0	3.2	3.0	1.0
Needles	2.5	5	6	.7	10	0	1	0	3.2	3.5	1.0
Oakland	.9	2	3	1.3	8	0	1	0	1.6	2.0	.3
Quincy	2.3	4	3	.9	13	0	11	0	3.1	3.3	.7
Redding	2.1	4	5	1.4	14	0	4	0	2.7	3.4	.8
Sacramento	2.2	9	7	1.2	11	0	1	0	2.8	4.8	.8
Salinas	2.3	1	8	1.1	16	0	5	0	3.2	5.9	.8
San Bernardino	1.9	4	5	1.2	11	0	0	0	2.6	3.4	1.0
San Diego	1.7	2	5	1.8	8	0	2	0	2.5	2.6	.8
San Luis Obispo	2.1	2	5	1.4	11	0	3	0	3.2	3.9	1.3
Santa Barbara	2.1	9	6	1.5	14	0	0	0	2.7	3.9	1.6
Santa Monica	2.0	4	5	1.5	15	0	0	0	3.2	4.2	.8
Santa Rosa	1.9	2	5	1.0	12	0	0	0	2.5	3.6	.9
Susanville	1.7	4	4	.6	12	0	0	0	1.8	2.9	1.1
Ukiah	1.1	3	5	1.0	6	0	1	0	2.2	2.6	.8

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet, including liquids.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis.

The practical reporting levels for these samples are: ^{89}Sr, 2.0 pCi/kg; ^{90}Sr, 1.0 pCi/kg; ^{226}Ra, 0.2 pCi/kg; ^{137}Cs, 7 pCi/kg; ^{95}Zr, 7 pCi/kg; ^{54}Mn, 7 pCi/kg; $^{141, 144}Ce$, 10 pCi/kg; and ^{40}K, 75 pCi/kg.

Table 3. Estimated daily intakes of radionuclides in California diets,[a] January-March 1972

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}Ce$	K[c]	Na	Ca
Bakersfield	2.3	0	11	0.9	12	0	0	0	3.0	4.2	1.1
Bishop	1.7	2	5	.5	9	0	4	0	2.1	2.2	.7
Brawley	1.9	11	9	1.5	10	0	0	0	2.4	3.2	1.1
Crescent City	2.3	7	7	1.6	16	0	5	0	3.0	4.5	1.0
Eureka	2.2	8	8	2.4	12	0	1	0	2.9	3.9	1.3
Fresno	1.8	0	10	2.3	8	0	3	0	2.7	2.9	1.1
Needles	2.5	4	5	1.0	6	0	0	0	3.0	4.2	.8
Oakland	1.0	4	3	.9	7	0	2	0	1.8	1.8	.3
Quincy	2.2	5	4	.9	15	0	2	0	3.1	2.9	.7
Redding	2.3	4	9	.9	12	0	4	0	2.9	3.2	1.4
Sacramento	2.2	5	7	2.1	12	0	0	0	3.0	5.0	.9
Salinas	2.4	9	4	1.4	16	0	3	0	3.3	6.2	.8
San Bernardino	2.2	4	8	1.3	9	0	0	0	3.2	4.0	1.7
San Diego	2.2	4	8	1.6	8	0	2	0	3.5	3.2	1.0
San Luis Obispo	2.1	4	6	1.7	8	0	2	0	3.2	4.1	1.3
Santa Barbara	2.2	7	9	1.7	6	2	2	0	2.8	4.3	1.7
Santa Monica	1.9	4	5	1.2	5	0	3	0	2.6	3.5	.6
Santa Rosa	1.8	5	5	1.4	7	0	3	0	2.4	3.5	.8
Susanville	1.9	2	6	1.4	11	0	2	0	2.5	3.2	.9
Ukiah	.8	4	9	1.4	4	0	1	0	1.6	2.2	1.5

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet, including liquids.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis.

The practical reporting levels for these samples are: ^{89}Sr, 2.0 pCi/kg; ^{90}Sr, 1.0 pCi/kg; ^{226}Ra, 0.2 pCi/kg; ^{137}Cs, 7 pCi/kg; ^{95}Zr, 7 pCi/kg; ^{54}Mn, 7 pCi/kg; ^{141}, ^{144}Ce, 10 pCi/kg; and ^{40}K, 75 pCi/kg.

Table 4. Estimated daily intakes of radionuclides in California diets,[a] April-June 1972

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}Ce$	K[c]	Na	Ca
Bakersfield	2.3	6	4	1.6	8	2	1	0	3.2	4.8	1.1
Bishop	1.7	2	4	1.2	5	2	1	0	2.5	2.3	.8
Brawley	2.1	7	7	2.2	1	0	4	0	2.7	4.3	1.5
Crescent City	2.3	13	11	1.8	17	3	2	0	3.0	4.2	1.2
Eureka	2.3	9	8	2.0	10	0	3	0	2.8	4.2	1.0
Fresno	1.9	5	5	1.5	6	0	4	0	2.5	2.9	1.0
Needles	2.5	9	4	1.1	5	0	4	0	2.8	3.8	1.0
Oakland	.7	1	2	.3	0	1	0	0	1.0	1.2	.2
Quincy	2.4	9	4	.9	8	0	3	0	2.9	3.0	.8
Redding	1.9	2	6	1.1	10	0	2	0	2.5	4.0	1.3
Sacramento	2.5	9	6	1.5	4	5	3	0	3.4	5.4	1.0
Salinas	2.4	7	5	.8	3	1	2	0	3.1	5.5	.8
San Bernardino	2.1	6	4	.5	6	9	1	0	3.1	4.0	1.0
San Diego	1.9	4	5	1.1	4	0	4	0	2.7	2.8	1.0
San Luis Obispo	2.2	12	8	1.4	10	0	0	0	3.2	4.7	1.4
Santa Barbara	2.5	3	6	1.8	4	5	4	0	3.0	4.3	1.1
Santa Monica	1.5	5	3	.9	6	1	1	0	2.3	2.6	.6
Santa Rosa	1.9	3	5	1.0	6	1	6	0	2.3	4.0	.8
Susanville	1.8	5	4	.8	9	0	2	0	2.2	3.1	.9
Ukiah	.8	9	3	1.3	2	0	2	0	1.5	2.8	.7

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet, including liquids.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis.

The practical reporting levels for these samples are: ^{89}Sr, 2.0 pCi/kg; ^{90}Sr, 1.0 pCi/kg; ^{226}Ra, 0.2 pCi/kg; ^{137}Cs, 7 pCi/kg; ^{95}Zr, 7 pCi/kg; ^{54}Mn, 7 pCi/kg; ^{141}, ^{144}Ce, 10 pCi/kg; and ^{40}K, 75 pCi/kg.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 1 (July–September 1971), and table 2 (October–December 1971), table 3 (January–March 1972), table 4 (April–June 1972), table 5 (July–September 1972), and table 6 (October–December 1972).

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action.

A summary of strontium-90 and cesium-137 intake trends in California diets from January 1964 through December 1972 is given in figures 2 and 3.

Table 5. Estimated daily intakes of radionuclides in California diets,[a] July-September 1972

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}Ce$	K[c]	Na	Ca
Bakersfield	2.3	13	5	1.1	11	3	3	0	3.4	4.7	1.3
Bishop	1.7	12	4	.9	10	3	0	0	2.7	2.6	1.0
Brawley	1.8	17	5	.9	5	1	6	0	2.5	3.8	.8
Crescent City	2.5	13	10	1.4	11	6	6	0	3.4	4.5	1.1
Eureka	2.3	12	6	1.2	13	3	2	0	2.7	4.7	.9
Fresno	2.0	14	4	1.2	5	1	6	0	2.7	2.9	1.1
Needles	2.3	14	5	.4	12	0	1	0	2.6	3.1	.8
Oakland	1.1	4	4	.4	10	2	1	0	1.2	2.7	.8
Quincy	2.1	14	4	1.3	8	4	1	0	2.9	2.7	.8
Redding	2.2	11	6	.8	10	2	2	0	2.6	3.6	1.6
Sacramento	2.5	12	5	1.4	5	2	4	0	3.4	5.9	.9
Salinas	2.5	15	11	1.7	10	1	6	0	3.4	7.2	.8
San Bernardino	1.9	12	5	1.4	7	3	0	0	2.2	3.0	1.4
San Diego	1.8	3	5	.8	3	3	0	0	2.5	2.8	.7
San Luis Obispo	2.2	4	3	.7	6	0	4	0	2.8	3.9	1.0
Santa Barbara	2.5	0	14	1.3	11	0	6	0	3.5	4.8	1.2
Santa Monica	2.4	12	2	1.2	11	0	4	0	3.0	3.1	1.2
Santa Rosa	2.0	0	17	.9	7	2	6	0	2.5	4.2	.9
Susanville	2.0	1	8	.6	6	0	2	0	2.3	2.8	.7
Ukiah	1.9	4	4	.3	8	0	2	0	2.4	3.7	.7

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet, including liquids.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis.

The practical reporting levels for these samples are: ^{89}Sr, 2.0 pCi/kg; ^{90}Sr, 1.0 pCi/kg; ^{226}Ra, 0.2 pCi/kg; ^{137}Cs, 7 pCi/kg; ^{95}Zr, 7 pCi/kg; ^{54}Mn, 7 pCi/kg; ^{141}, ^{144}Ce, 10 pCi/kg; and ^{40}K, 75 pCi/kg.

Table 6. Estimated daily intakes of radionuclides in California diets,[a] October-December 1973

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}Ce$	K[c]	Na	Ca
Bakersfield	2.3	2	5	.7	32	0	6	0	3.4	4.3	1.0
Bishop	1.9	2	5	.9	4	0	0	0	2.6	2.3	1.0
Brawley	1.8	4	9	.6	22	0	1	0	2.8	3.0	1.2
Crescent City	2.5	2	9	1.5	45	0	9	0	2.6	3.5	1.0
Eureka	2.2	3	4	1.0	49	0	7	0	2.8	4.6	.8
Fresno	1.9	0	5	.9	32	0	7	0	2.6	2.7	1.0
Needles	2.2	4	3	1.0	1	3	0	0	2.2	2.6	.7
Oakland	2.0	8	4	.6	37	0	2	0	2.3	2.4	.8
Quincy	1.7	1	3	.7	2	3	0	0	2.2	2.8	.6
Redding	2.0	3	4	.9	3	0	0	0	2.5	2.9	1.2
Sacramento	2.6	8	4	1.4	5	0	2	0	3.5	4.7	1.1
Salinas	2.4	10	5	1.4	4	1	2	0	3.3	7.8	.7
San Bernardino	2.1	9	5	1.1	4	0	3	0	2.8	3.4	1.9
San Diego	1.7	3	3	1.2	5	0	1	0	2.5	2.7	.8
San Luis Obispo	2.1	9	6	1.7	5	0	4	0	3.2	4.5	1.4
Santa Barbara	2.3	5	5	1.7	1	1	2	0	2.7	3.0	1.2
Santa Monica	1.8	6	4	.9	5	4	1	0	2.7	3.3	.8
Santa Rosa	2.3	3	4	.8	7	2	3	0	1.9	2.7	.8
Susanville	1.8	2	3	1.0	3	3	0	0	2.3	2.8	.8
Ukiah	1.9	2	3	.9	7	1	2	0	2.0	2.7	1.0

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet, including liquids.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis.

The practical reporting levels for these samples are: ^{89}Sr, 2.0 pCi/kg; ^{90}Sr, 1.0 pCi/kg; ^{226}Ra, 0.2 pCi/kg; ^{137}Cs, 7 pCi/kg; ^{95}Zr, 7 pCi/kg; ^{54}Mn, 7 pCi/kg; ^{141}, ^{144}Ce, 10 pCi/kg; and ^{40}K, 75 pCi/kg.

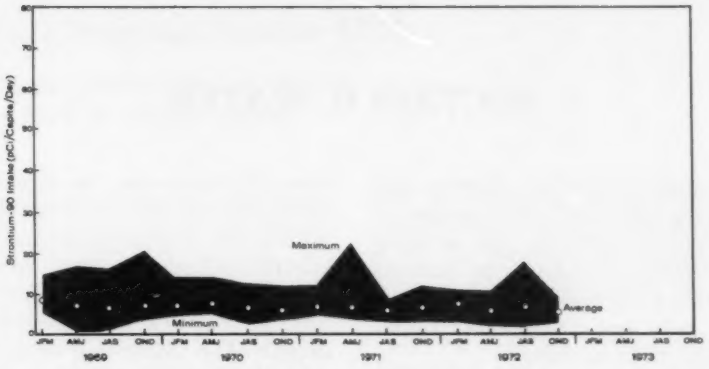

Figure 2. Average and ranges of strontium-90 intake in California diets

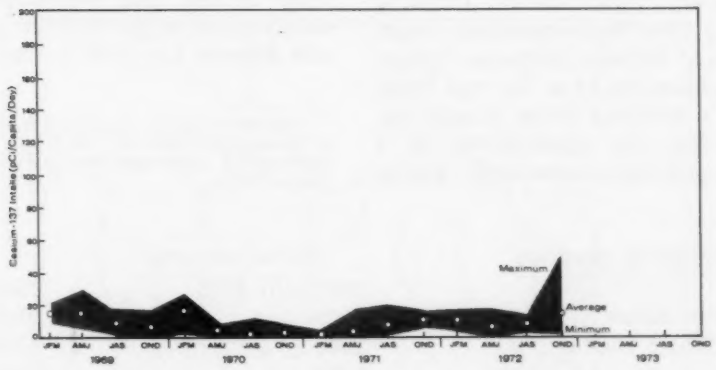

Figure 3. Average and ranges of cesium-137 intake in California diets

REFERENCE

(*1*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH, BUREAU OF RADIOLOGICAL HEALTH. Radiol Health News 4:4 (October 1965). 2151 Berkeley Way, Berkeley, Calif. 94704.

Previous coverage in *Radiation Data and Reports:*

Period	Issue
January–June 1971	December 1972

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	1971 and 1972	November 1973
Colorado River Basin	1968	March 1972
Community Water Supply	1968	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	1971	February 1973
Minnesota	July 1970–June 1971	November 1972
New York	July–December 1971	August 1973
North Carolina	1968–1970	September 1972
Radiostrontium in Tap Water, *HASL*	January–December 1972	December 1973
Tritium Surveillance System	April–June 1973	October 1973
Washington	July 1970–June 1971	August 1973

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Water Surveillance Programs, October 1973

National Environmental Research Center—Las Vegas, Environmental Protection Agency

The Water Surveillance Network, operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 59 sampling locations (figures 1 and 2) in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site.

In the event of a release of radioactivity from the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations. Additional water sampling networks are operated in support of AEC operations in areas other than the NTS when requested.

During nuclear testing at the NTS in October 1961, the WSN was established with routine samples collected monthly. This sampling frequency was continued until October 1, 1973,

[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

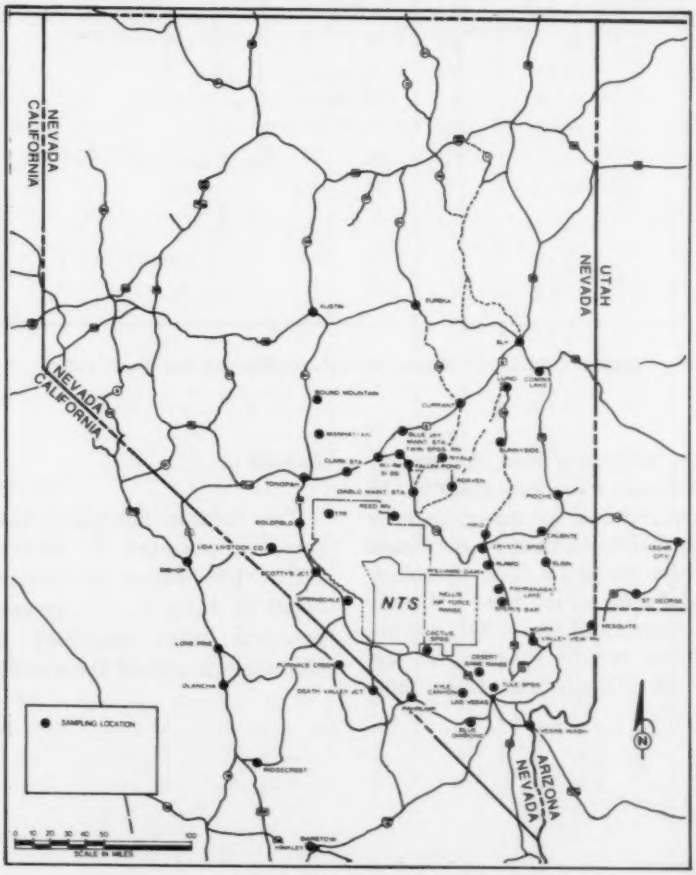

Figure 1. NERC-LV Water Surveillance Network

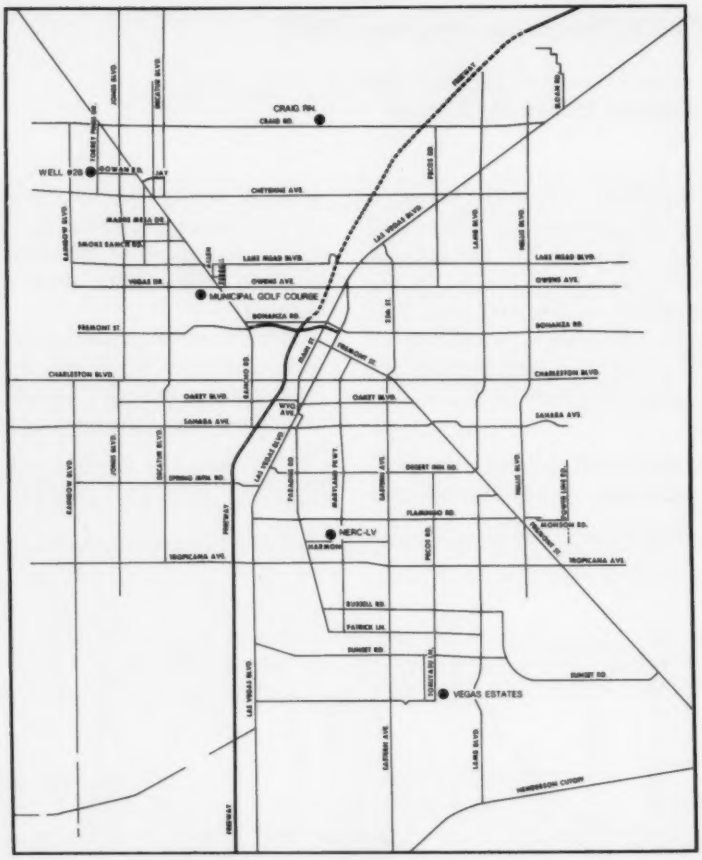

Figure 2. NERC-LV Water Surveillance Network-Las Vegas Valley

when the collection frequency was changed to quarterly. This change was implemented to economize on operations and yet maintain adequate sampling capability in case of a release of radioactivity from the NTS. The sampling and analytical procedures, which have not been changed with this revision of the WSN, are included with the water results reported in the July 1973 issue of "Radiation Data and Reports."

Results

The routine analytical results of all water samples collected in October 1973 by the NERC-LV water surveillance network are listed in table 1. No gamma-emitting fission products were identified by gamma spectrometry in any of the samples.

Table 1. Water surveillance results, October 1973

Location	Date collected (1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
California:					
Bishop:					
Fish and Game Office	24	23	<1.3	<3.2	NA
Death Valley Junction:					
Lila's Cafe	25	23	<4.5	10 ±3.9	<240
Furnace Creek:					
Pond	25	21	<3.7	8.7±3.7	NA
Visitor Center	25	27	<3.6	9.1±3.7	NA
Hinkley:					
Bill Nelson Dairy	23	23	7.3±4.8	6.9±3.6	NA
Lone Pine:					
Forest Service Ranger Station	24	24	1.8±1.7	<3.2	NA
Olancha:					
Haiwee Reservoir	24	21	6.3±4.1	5.6±3.4	NA
Ridgecrest:					
City Hall	24	23	<3.0	<3.3	NA
Nevada:					
Adaven:					
Canfield Ranch	3	22	<2.7	3.2±32.	NA
Alamo:					
Pahranagat Lake	5	21	19 ±8.4	35 ±5.1	NA
Sheri's Bar	5	23	<2.2	3.9±3.3	NA
Williams Dairy	1	23	5.0±4.4	9.4±3.7	NA
Austin:					
Nevada National Bank	4	27	23 ±6.7	14 ±3.8	NA
Blue Diamond:					
Post Office	16	23	<2.5	<3.3	<260
Blue Jay Highway:					
Maintenance Station	10	23	4.9±3.7	5.7±3.4	NA
Cactus Springs:					
Mobil Service Station	15	27	3.7±2.5	<3.3	<260
Caliente:					
Agricultural Extension Station	4	23	5.3±3.5	7.2±3.5	NA
Clark Station:					
Five Mile Ranch	11	27	<2.0	4.1±3.3	NA
Currant:					
Currant Ranch Cafe	10	27	3.9±4.8	<3.3	NA
Diablo:					
Highway Maintenance Station	2	23	<1.9	5.7±3.4	NA
Reed Ranch	1	21	14 ±6.4	17 ±4.1	NA
Elgin:					
Water tower	4	23	<3.5	7.6±3.6	NA
Ely:					
Chevron Service Station	16	24	4.2±2.8	3.1±3.1	NA
Comins Lake	16	21	8.3±4.4	15 ±4.0	NA
Eureka:					
Highway Maintenance Station	1	24	5.2±3.9	5.4±3.4	NA
	4	24	7.1±4.1	7.2±3.5	NA
Goldfield:					
Chevron Service Station	3	23	6.7±4.7	3.6±3.3	NA
Hiko:					
Crystal Springs	1	27	5.4±3.6	4.9±3.3	NA
Schofield Dairy	1	23	24 ±8.3	27 ±4.6	NA
Las Vegas:					
Craig Ranch Golf Course	23	23	10 ±4.3	4.0±3.3	<260
Desert Game Range	15	23	2.8±2.7	<3.1	<260
Lab II NERC	23	24	<3.5	7.0±3.6	980±270
Lake Mead Vegas wash	23	21	5.6±4.4	5.8±3.5	980±270
Las Vegas Water District Well 28	23	23	5.4±3.2	3.9±3.2	<260
Municipal Golf Course	23	23	3.1±2.5	<3.3	<260
Tule Springs	15	23	<2.4	<3.1	<260
Tule Springs Pond	15	21	4.3±2.8	<3.3	NA
Vegas Estates	23	23	4.6±4.4	12 ±4.0	<260
Lida:					
Lida Livestock Company	3	27	<2.4	<3.2	NA
Pond at storage tank	3	21	<2.4	5.9±3.4	NA
Lund:					
Gardner Grocery	17	23	<1.8	3.8±3.3	NA
Manhattan:					
Country store	4	23	9.5±5.3	4.3±3.3	NA
Mesquite:					
Hughes Bros. Dairy	16	23	<3.5	4.7±3.4	NA
Moapa:					
Pedersen Valley View Ranch	16	27	<3.9	10 ±3.7	NA
Mt. Charleston:					
Kyle Canyon Fire Station	15	27	2.9±2.5	<3.3	<260
Nyala:					
Sharp's Ranch	3	23	<2.1	<3.2	NA
Pahrump:					
Texaco Service Station	16	23	2.7±2.3	<3.3	NA

See footnotes end of table.

Table 1. Water surveillance results, October 1973—continued

Location	Date collected (1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
Pioche:					
County Courthouse	3	24	<2.0	4.9±3.3	NA
Round Mountain:					
Mobile Service Station	4	27	<2.2	<3.2	NA
Scotty's Junction:					
Chevron Service Station	3	23	<3.9	9.5±3.7	<240
Springdale:					
Pond	17	21	4.8±4.1	8.8±3.7	NA
Sunnyside:					
Adam McGill Reservoir	17	21	5.0±3.5	3.9±3.2	NA
Wildlife Management Headquarters	17	27	3.9±2.7	<3.3	NA
Tonopah:					
Jerry's Chevron Station	4	23	6.1±3.8	5.0±3.3	NA
Tonopah Test Range CP–1	11	23	<3.4	3.7±3.3	NA
Warm Springs:					
Fallini's Pond	3	21	6.5±4.9	13 ±3.9	NA
Service Station and Cafe	11	27	18 ±8.3	28 ±4.8	NA
Twin Springs Ranch	3	23	<3.2	5.9±3.4	NA
Utah:					
Cedar City:					
M. D. Baldwin residence	17	24	<2.0	<3.1	NA
St. George:					
R. Cox Dairy	17	24	1.8±1.6	<3.2	NA

[a] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well.
24—Multiple supply mixed (a water sample consisting of mixed or multiple sources of water such as well and spring).
27—Spring.

[b] Two-sigma counting error provided when available.
NA, not analyzed.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Pan American Health Organization, and the California Department of Health.

In addition to those programs presented in this issue, the following programs were covered previously in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	1971	August 1973
Mexican air monitoring program	January–June 1973	December 1973
Plutonium in airborne particulates	October–December 1972	June 1973
Surface air sampling program, 80th Meridian Network, *HASL*	1971	September 1973

1. Radiation Alert Network October 1973

Eastern Environmental Radiation Facility
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which gathers samples at 68 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. The airborne particulate samples and precipitation samples are sent to the Eastern Environmental Radiation Facility for further analysis. All field estimate results are reported to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily measurements is available upon request from the Eastern Environmental Radiation Facility, Montgomery, Ala. 36109. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate and laboratory techniques during October 1973.

The Office of Radiation Programs is in the process of modifying the air program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.

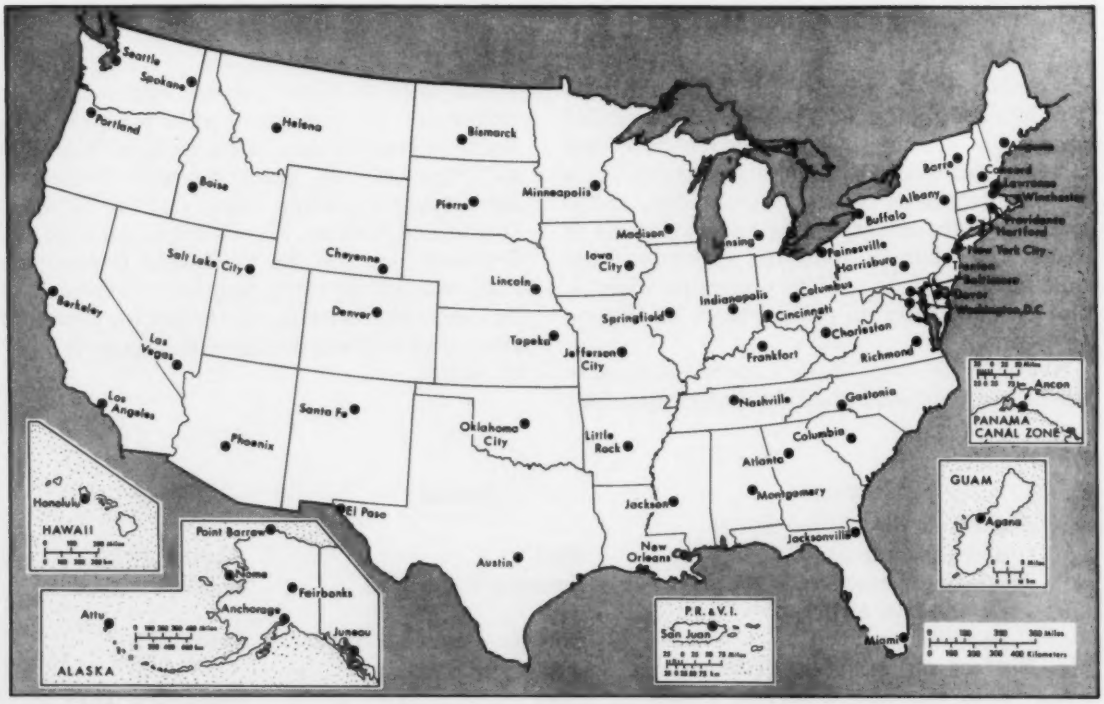

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, October 1973

Station location [a]	Number of samples	Gross beta radioactivity (pCi/m³)						Precipitation	
		5-hour field estimate			Laboratory measurement			Laboratory estimate of deposition	
		Maximum	Minimum	Average[b]	Maximum	Minimum	Average [b]	Depth (mm)	Total deposition (nCi/m²)
Ala: Montgomery	14	6	0	2	0.05	<0.01	0.02	10	0.05
Alaska: Anchorage	1				.02	.02	.02		
Calif: Berkeley	9	0	0	0	.10	<.01	.04	9	.02
Los Angeles	9	2	0	1	.07	.02	.04		
Colo: Denver	9	2	1	1	.05	.02	.04	10	.06
Ind: Indianapolis	19	2	0	1	.07	<.01	.03		
Nev: Las Vegas	9	1	0	1	.04	.02	.03		
N. Mex: Santa Fe	4	1	1	1	.03	.03	.03		
N.Y: Buffalo	9	1	0	0	.06	.01	.03		
N. Dak: Bismarck	9	7	0	1	.09	.01	.04	44	.25
Ohio: Columbus	3	1	0	1	.03	.02	.03		
Okla: Oklahoma City	4	1	0	1	.02	.01	.02		
Oreg: Portland	22	1	0	0	.10	<.01	.02		
Pa: Harrisburg	20	3	0	1	.06	.01	.03		
S.C: Columbia	9	2	0	1	.04	<.01	.03	29	.07
Tex: Austin	2	2	1	2	.01	.01	.01		
Network summary	148	7	0	1	0.10	<0.01	0.03	20	0.09

[a] The remaining stations are standby stations.
[b] The monthly average is calculated by weighting the estimates of individual air samples with length of sampling period.

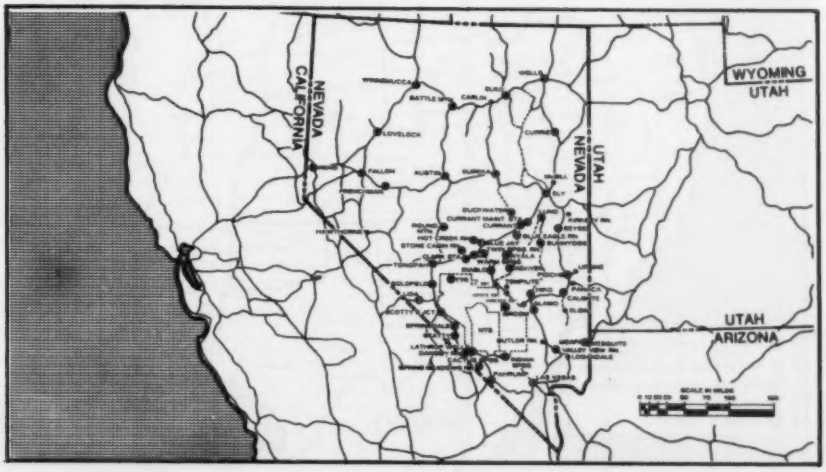

Figure 2. NERC-LV Air Surveillance Network stations in Nevada

2. Air Surveillance Network, October 1973

National Environmental Research Center—Las Vegas, Environmental Protection Agency

The Air Surveillance Network (ASN),[1] operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 49 active and 72 standby sampling stations located in 21 Western States (figures 2 and 3). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), and at any other designated testing sites.

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being changed over periods generally ranging from 48 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

[1] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

Results

Table 2 presents the average gross beta concentrations in air for each of the network stations. The minimum reporting concentration for gross beta activity is 0.1 pCi/m³. For reporting purposes, concentrations less than 1.0 pCi/m³ are reported to 1 significant figure, and those equal to or greater than 1.0 pCi/m³ are reported to 2 significant figures. For averaging purposes individual concentration values less than the minimum detectable concentration (—0.03 pCi/m³ for a 700 m³ sample) are set equal to the minimum detectable concentration (MDC). Reporting and rounding-off conventions are indicated as follows:

Figure 3. NERC-LV Air Surveillance Network stations outside Nevada

Concentration (pCi/m^3)	Reported value of concentration above MDC (pCi/m^3)	Reported value of concentration below MDC (pCi/m^3)
<0.05	<0.1	<0.1
≥ 0.05 <0.15	0.1	<0.1
≥ 0.15	As calculated and rounded	$<$calculated MDC

As shown by table 2, the highest gross beta concentration at continuously operated stations within the network was 0.3 pCi/m^3 at Caliente, Nev. No radionuclides were identified by gamma spectrometry on any filters or charcoal cartridges during October.

The 72 standby stations were activated on September 28 for one week of operation to check equipment and gather background radiation data. This activation resulted in two samples being collected at most of the standby stations during October 1973.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Table 2. Summary of gross beta radioactivity concentrations in air, October 1973

Location		Number of samples	Concentration (pCi/m^3)		
			Maximum	Minimum	Average
Ariz:	Kingman	31	0.2	<0.1	0.1
	Phoenix	12	.1	<.1	<.1
	Seligman	14	.1	<.1	.1
	Winslow	2	<.1	<.1	<.1
Ark:	Little Rock	3	<.1	<.1	.1
Calif:	Baker	23	.1	<.1	.1
	Barstow	14	.2	<.1	.1
	Bishop	14	.2	<.1	.1
	Death Valley Junction	13	.1	<.1	.1
	Furnance Creek	14	.1	<.1	.1
	Indio	5	<.1	<.1	<.1
	Lone Pine	12	.1	<.1	.1
	Needles	13	.1	<.1	.1
	Ridgecrest	13	.1	<.1	.1
	Shoshone	14	.1	<.1	.1
Colo:	Denver	2	<.1	<.1	<.1
	Durango	2	.1	<.1	<.1
Idaho:	Boise	2	.1	<.1	.1
	Idaho Falls	2	.1	<.1	.1
	Preston	2	.1	<.1	.1
	Twin Falls	2	.4	.2	.3
Iowa:	Iowa City	2	<.1	<.1	<.1
	Sioux City	2	<.1	<.1	<.1
Kans:	Dodge City	2	<.1	<.1	<.1
La:	Monroe	2	<.1	<.1	.1
	New Orleans	4	<.1	<.1	.1
Minn:	Minneapolis	2	<.1	<.1	<.1
Mo:	Clayton	2	<.1	<.1	<.1
	Joplin	2	<.1	<.1	<.1
Nebr:	North Platte	2	<.1	<.1	<.1
Nev:	Alamo	15	.1	<.1	.1
	Austin	8	<.1	<.1	<.1
	Battle Mountain	2	<.1	<.1	<.1
	Beatty	15	.2	<.1	.1
	Blue Eagle Ranch (Currant)	14	.1	<.1	.1
	Blue Jay	14	.2	<.1	.1
	Caliente	12	.3	<.1	.1
	Currant Ranch	14	.1	<.1	<.1
	Currie	2	.1	<.1	.1
	Diablo	14	.1	<.1	.1
	Duckwater	16	.1	<.1	.1
	Elko	2	.1	<.1	.1
	Ely	14	.1	<.1	<.1
	Eureka	14	.1	<.1	<.1
	Fallini's Twin Springs Ranch	14	.1	<.1	.1
	Fallon	2	.1	<.1	.1
	Frenchman Station	2	.1	.1	.1
	Geyser Ranch	13	.1	<.1	.1
	Goldfield	14	.1	<.1	.1
	Groom Lake	9	.2	<.1	.1

Table 2. Summary of gross beta radioactivity concentrations in air October 1973—continued

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Nev:	Hiko	14	0.1	<0.1	0.1
	Indian Springs	14	<.1	<.1	<.1
	Las Vegas	13	.2	<.1	.1
	Lathrop Wells	17	.1	<.1	.1
	Lida	22	.1	<.1	.1
	Lovelock	2	.1	<.1	.1
	Lund	14	.1	<.1	.1
	Mesquite	14	.1	<.1	<.1
	Nyala	14	.1	<.1	.1
	Pahrump	14	.1	<.1	.1
	Pioche	14	.1	<.1	<.1
	Reno	2	.1	<.1	.1
	Round Mountain	14	.1	<.1	<.1
	Scotty s Junction	14	.1	<.1	.1
	Stone Cabin Ranch	14	.2	<.1	.1
	Sunnyside	11	.1	<.1	<.1
	Tonopah	14	.1	<.1	.1
	Tonopah Test Range	14	.1	<.1	.1
	Warm Springs	11	.1	<.1	.1
	Warm Springs Ranch	14	.1	<.1	.1
	Wells	2	.1	<.1	.1
	Winnemucca	2	.1	<.1	.1
N. Mex:	Albuquerque	4	.1	<.1	.1
	Carlsbad	3	<.1	<.1	.1
Okla:	Muskogee	2	<.1	<.1	<.1
Oreg:	Burns	2	.1	<.1	.1
	Medford	2	<.1	<.1	<.1
S. Dak:	Aberdeen	2	<.1	<.1	<.1
	Rapid City	2	<.1	<.1	<.1
Tex:	Abilene	2	<.1	<.1	<.1
	Amarillo	2	<.1	<.1	<.1
	Austin	1	<.1	<.1	<.1
	Fort Worth	2	<.1	<.1	<.1
Utah:	Bryce Canyon	3	<.2	<.1	.1
	Cedar City	10	.1	<.1	.1
	Delta	25	<.2	<.1	.1
	Dugway	2	.1	<.1	.1
	Enterprise	2	.1	<.1	.1
	Garrison	16	.1	<.1	.1
Utah:	Logan	2	.1	<.1	.1
	Milford	14	.1	<.1	.1
	Monticello	2	<.1	<.1	<.1
	Parowan	2	.1	<.1	.1
	Provo	2	.1	<.1	.1
	Salt Lake City	2	.1	.1	.1
	St. George	27	.1	<.1	.1
	Vernal	2	<.1	<.1	<.1
Wash:	Seattle	1	<.1	<.1	<.1
	Spokane	3	<.1	<.1	<.1
Wyo:	Rock Springs	2	<.1	<.1	<.1
	Worland	2	.1	<.1	.1

3. Canadian Air and Precipitation Monitoring Program,[3] October 1973

Radiation Protection Bureau
Department of National Health and Welfare

The Radiation Protection Bureau of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Atmospheric Environment Service of the Department of the Environment. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in Reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

[3] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for October 1973 are presented in table 3.

Table 3. Canadian gross beta radioactivity in surface air and precipitation, October 1973

Location	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.01	0.01	0.01	NS	NS
Coral Harbour	5	.01	<.01	.01	1.4	0.2
Edmonton	4	.02	.01	.01	13.3	.1
Ft. Churchill	4	.01	<.01	.01	8.2	.6
Fredericton	3	.02	.01	.01	7.8	.3
Goose Bay	3	.03	.01	.02	6.9	.5
Halifax	5	.03	.01	.02	5.0	.6
Inuvik	5	.02	.01	.01	16.5	.3
Montreal	5	.02	.01	.01	6.9	.4
Moosonee	5	.03	.01	.02	8.1	.3
Ottawa	1	.02	.02	.02	6.7	.7
Quebec	4	.02	.01	.01	2.7	.3
Regina	3	.02	.01	.01	69.6	.4
Resolute	4	.02	.01	.01	11.0	.7
St. John's, Nfld.	NS	NS	NS	NS	1.3	.2
Saskatoon	3	.02	.01	.01	NS	NS
Sault Ste. Marie	3	.03	.02	.03	10.3	1.0
Thunder Bay	4	.04	<.01	.02	13.9	.9
Toronto	4	.02	.01	.02	8.3	1.2
Vancouver	4	.01	<.01	.01	14.8	1.7
Whitehorse	4	.02	<.01	.01	9.3	.2
Windsor	NS	NS	NS	NS	10.7	.6
Winnipeg	4	.02	.01	.02	20.0	.7
Yellowknife	3	.01	<.01	.01	9.5	.4
Network summary	84	0.04	<0.01	0.01	11.9	0.6

NS, no sample.

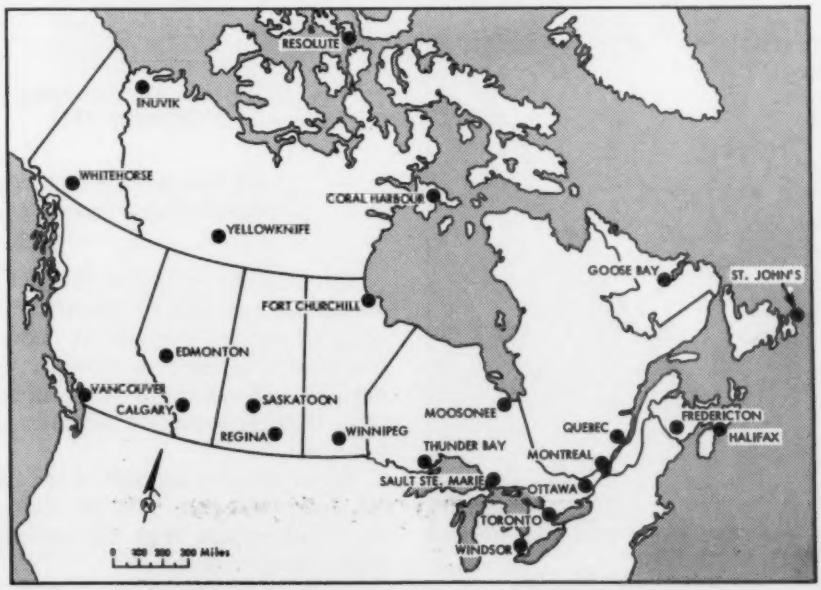

Figure 4. Canadian air and precipitation monitoring program

4. Pan American Air Sampling Program October 1973

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The October 1973 air monitoring results from the participating countries are given in table 4.

Figure 5. Pan American Air Sampling Program stations

Table 4. Summary of gross beta radioactivity in Pan American surface air, October 1973

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average*
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	1	0.01	0.01	0.01
Chile:	Santiago	31	.07	.00	.01
Colombia:	Bogota	21	.08	.00	.00
Ecuador:	Cuenca	5	.02	.01	.01
	Guayaquil	20	.02	.00	.01
	Quito	19	.03	.00	.00
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	11	.01	.00	.01
West Indies:	Trindad	0			
Pan American summary		108	0.08	0.00	0.01

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

5. California Air Sampling Program October 1973

Radiologic Health Section California Department of Health

The Radiologic Health Section of the California Department of Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 6.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Health where they are analyzed for their radioactive content.

Airborne particles are collected by a con-

Figure 6. California air sampling program stations

tinuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity 72 hours after the end of the collection period. The daily samples then are composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 5 presents the monthly gross beta radioactivity in air for October 1973. The monthly sample results are presented quarterly.

Table 5. Gross beta radioactivity in California air October 1973

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	30	1.29	0.05	0.27
Barstow	31	.76	.05	.20
Berkeley	30	.23	.00	.09
El Centro	14	.50	.04	.18
Eureka	30	.19	.01	.05
Fresno	30	1.20	.06	.19
Los Angeles	30	.21	.00	.07
Redding	28	.34	.06	.12
Sacramento	30	.96	.00	.16
Salinas	30	4.93	.14	.73
San Bernardino	30	.78	.07	.17
San Diego	30	.48	.00	.14
San Luis Obispo	30	.60	.01	.18
Santa Rosa	31	.42	.00	.11
Summary	404	4.93	0.00	0.19

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RDP-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental radioactivity data follow for Lawrence Berkeley Laboratory and the Savannah River Plant.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Lawrence Berkeley Laboratory[2] January–December 1971

University of California
Berkeley, Calif.

The Lawrence Berkeley Laboratory (LBL) formerly known as the Berkeley site of the Lawrence Radiation Laboratory is situated on the western slope of the range of hills running along the eastern side of San Francisco Bay. The laboratory area is largely separate from the main campus of the University (figure 1).

To the north and south of the laboratory area are residential areas of the cities of Berkeley and Oakland. The major part of the Berkeley campus of the University of California is on the west. On the east are the Lawrence Hall of Science and the Space Sciences Laboratory; beyond them lies uninhabited watershed land and the Tilden Regional Park.

The most prevalent wind direction is westerly. During the summer months, the afternoon sea breeze establishes a very pronounced prevailing westerly wind direction. At other times, the direction is less predictable. Annual rainfall is 23 inches, almost all of which falls between November 1 and May 1. The prevailing wind direction during precipitation is southerly.

The laboratory carries on a wide ranging program of general research in the fields of both physical and biological sciences. Facilities include a number of large accelerators, and various physics, chemistry, biology and medical research laboratories.

The assessment of possible impact of the laboratory on its environment is carried out by two separate groups. All measurements of possible releases of radioactive materials to the environment are made by the Safety Services Department. Measurements of potential gamma and neutron exposures from the operation of

[2] Summarized from "Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites, Lawrence Berkeley Laboratory," January-December 1971, Berkeley, Calif.

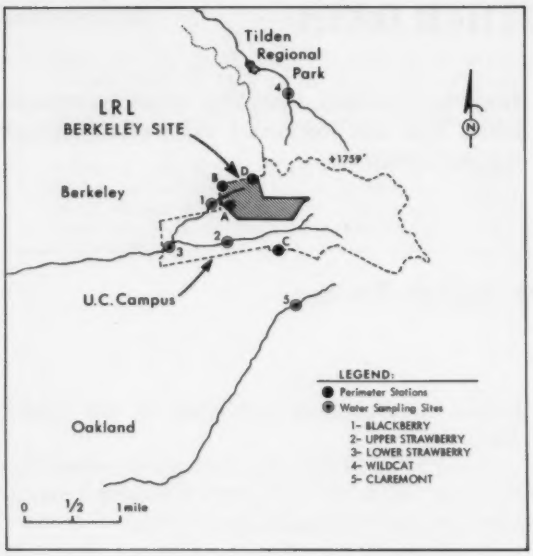

Figure 1. Environmental sampling locations at the Lawrence Berkeley Laboratory

the many accelerators are carried out by the Health Physics Department.

Neutron and gamma-ray fields are measured at each of the four perimeter stations as well as at several locations within the site. Background measurements are obtained from a leased building used as a low-level counting room in downtown Berkeley. This building is remote from the main LBL site and measurements are not influenced by accelerator operations.

At each station, gamma measurements are made by a recording G-M detector, standardized with a calibrated radium source.

Several neutron detectors are employed at each station. The primary detector is a BF_3 gas proportional counter in a 2½-inch thick paraffin-lined moderator. This detector is sensitive in the region from 0.1 to 20 MeV, where 75 percent of the biologically significant neutrons exist. A polyethylene-lined proton recoil neutron detector provides a measure of the energy flux density. The ratio of energy flux density to neutron flux density gives the average neutron energy which allows conversion of the data to dose in rems. Cobalt disks in moderators are maintained as long term integrating neutron monitors at many sites throughout the laboratory as well as at each perimeter station.

Cosmic ray intensity is continuously monitored by a meson detector with an effective angle of acceptance of 2.3 steradians (in the upward direction). This provides information on the background neutron levels contributed by cosmic rays.

At each station, total radiation levels are well below the standards set for the general public by the International Commission on Radiological Protection and National Council on Radiation Protection and Measurements (NCRP). Results are presented in table 1.

Atmospheric sampling

Our basic policy has long been to prevent, as far as possible, any release of radioactive material to the environment, no matter how small. No deliberate releases are sanctioned, except where no practical method for containment has yet been developed and quantities are small compared with standards established by the ICRP and AEC.

Table 1. Neutron and gamma levels, Lawrence Berkeley Laboratory January-December 1971

Perimeter station	January-June		July-December	
	Total beta-gamma exposure (mrem) (background subtracted)	Total fast neutron exposure (mrem) [a] (background subtracted)	Total beta-gamma exposure (mrem) (background subtracted)	Total fast-neutron exposure (mrem) [a] (background subtracted)
A	9.75	85.6	7.21	182.4
B	9.74	35.8	[b]	46.8
C	[b]	13.0	4.39	.8
D	[c]	92.6	[c]	21.2

[a] 2.45×10^7 n/cm² = 1 rem.
[b] Detector not in service.
[c] Background.

The most sensitive measurements of releases are those taken closest to the source itself, before dilution makes detection of small quantities more difficult. Our stack sampling program, therefore, provides the most useful information for controlling releases to the atmosphere. Over 100 separate exhausts from hoods and glove box manifolds are sampled. The total quantities released from these stacks during January–June 1971 were 0.7 microcuries of alpha, 0.15 curies of carbon-14, 2.1 curies of tritium and 166 microcuries of other beta emitters. For the July–December period, the total quantities released were <0.1 microcuries of alpha, 8.3 millicuries of carbon-14, 5.9 curies of tritium and 55 microcuries of other beta emitters. The average concentration in the total exhaust, *before* any dilution by the atmosphere, was 9 percent for the January–June period and 6 percent for July–December period of the permissible concentrations for offsite breathing zone air as stated in the AEC standards.

In addition to the careful sampling of stacks, an environmental air sampling program is carried on to make sure no undetected releases occur. These samples provide a direct measurement of possible exposure to the nearby population. Results from these samples are tabulated in some detail in table 2. The sampling stations designated "local area" are outdoor locations within the site boundaries and provide samples of the onsite atmosphere. The "perimeter" samples are taken at the boundary line of University property, in the direction of populated areas. From these samples, it is apparent that there has been no significant exposure from radioactive materials released by LBL.

At each of these environmental stations, rain or dry "fallout" is also collected in 15-inch diameter containers. If no rain has fallen, the containers are rinsed out with water to obtain a sample. Table 3 shows a summary of atmospheric deposition. There is no indication that any of this originated at LBL.

Table 2. Atmospheric monitoring, LBL January-December 1971

Sampling locations (number of locations)	Number of samples	Average concentration (pCi/m³)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
January-June 1971:					
Local area (10)	249	0.000	<0.005	0.26	1.00
Perimeter					
A	26	.000	<.005	.24	.68
B	26	.000	<.005	.29	.86
C	26	.000	<.005	.28	.82
D	25	.000	<.005	.35	1.26
Summary	103	.000		.29	
July-December 1971:					
Local area (10)	247	.000	.006	.12	.42
Perimeter					
A	25	.000	.005	.13	.41
B	25	.001	<.005	.12	.29
C	23	.000	.005	.12	.30
D	25	.000	<.005	.17	.40
Summary	98	.000		.14	
AEC standard for offsite breathing zone air		0.020		10.0	

Table 3. Total deposition, LBL January-December 1971

Sampling locations (number of locations)	Number of samples	Average deposition (nCi/m²)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
January-June 1971:					
Local area (9)	54	0.019	0.062	6.199	7.72
Perimeter (4)	23	.015	.054	7.141	10.5
July-December 1971:					
Local area (9)	54	.027	.039	1.30	2.2
Perimeter (4)	24	.054	.073	3.60	7.33

Water sampling

All liquid waste known to be radioactive is collected, solidified, and shipped away. Other liquid wastes are discharged directly to the municipal sewer system. There are two outfalls, each of which is monitored by a continuous proportional sampling system to insure that no significant quantities have been discharged accidentally. The average concentrations observed for January–December are shown in table 4. The total concentration (alpha-plus-beta) in sewage is ≤1 percent of the AEC standard for discharges to sewers.

The storm drainage from the laboratory flows into the surface stream system. These surface streams are exposed as they run through the University property and are sampled at three places. Results are listed as

Table 4. Summary of sewer data, LBL, January-December 1971

Location	Total quantities discharged 6 months			Number of samples	Net concentrations (pCi/liter)			
					Alpha		Beta	
	Total volume (Ml)	Total alpha radioactivity (μCi)	Total beta radioactivity (mCi)		Average	Maximum	Average	Maximum
January-June 1971:								
Hearst	131.0	8.6	4.78	21	0.07	2.0	36.1	550
Strawberry	54.6	12.0	1.06	24	.22	2.8	19.4	108
Summary	185.6	20.6	5.79		.11		31.2	
July-December 1971:								
Hearst [a]	144	34	1.41	15	.24	2.7	9.8	18
Strawberry	80	142	1.34	24	1.78	26	16.8	110
Summary	224	176	2.75		.79		12.3	
AEC standard for sewer discharges					400		3 000	

[a] The Hearst sewer sampler was inoperative for one-third of this period. Quantities reported are estimates made by assuming that the average concentrations during the down period were the same as when the sampler was operating.

Table 5. Water monitoring, Lawrence Berkeley Laboratory, January-December 1971

Type and source of sample	Number of samples	Concentration (pCi/liter)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
January-June 1971:					
Surface water:					
Onsite streams:					
Blackberry	26	0.18	1.6	3.74	15.3
Lower Strawberry	26	.29	2.1	10.12	83.4
Upper Strawberry	26	0	1.2	2.67	9.6
Summary	78	.16		5.51	
Offsite streams:					
Claremont	26	.55	2.5	2.43	7.4
Wildcat	26	.12	3.8	2.10	7.6
Summary	52	.34		2.26	
Tap water	25	0	.48	1.52	2.6
July-December 1971:					
Onsite streams:					
Blackberry	25	.07	.7	2.70	8.8
Lower Strawberry	25	.23	1.6	6.99	17.1
Upper Strawberry	25	.30	1.5	3.26	8.8
Summary	75	.20		4.32	
Offsite streams:					
Claremont	25	.20	2.6	1.96	4.9
Wildcat	25	.07	.9	2.32	4.3
Summary	50	.13		2.14	
Tap water	23	.06	.5	1.52	2.8
AEC standard for offsite drinking water		30.0		100.0	

"onsite streams" in table 5. Two nearby offsite streams are also sampled to provide a comparison. All are very safely below the standard for drinking water.

Previous coverage in *Radiation Data and Reports:*

Period	Issue
July–December 1970	October 1971

2. Savannah River Plant[3] January–December 1971

E. I. DuPont de Nemours
Aiken, S.C.

The Savannah River Plant (SRP) occupies an area of about 315 square miles along the Savannah River, principally in Aiken and Barnwell Counties of South Carolina. Most of the plant's environs are rural. Population density of nearby counties ranges from 10 to over 400 people per square mile with the greatest concentration in Augusta, Ga. and its suburbs, which has a population approaching 200 000. The countryside is predominantly forested. Farming is diversified, the main crops being cotton, soybeans, corn, and small grains. Production of beef cattle has rapidly expanded during the past few years. The climate is mild, with an average frost-free season of approximately 246 days. Rainfall averages about 45 inches that is fairly evenly distributed throughout the year.

[3] Summarized from "Environmental Monitoring in the Vicinity of the Savannah River Plant," Annual Report for 1971 (DPSPU 72-30).

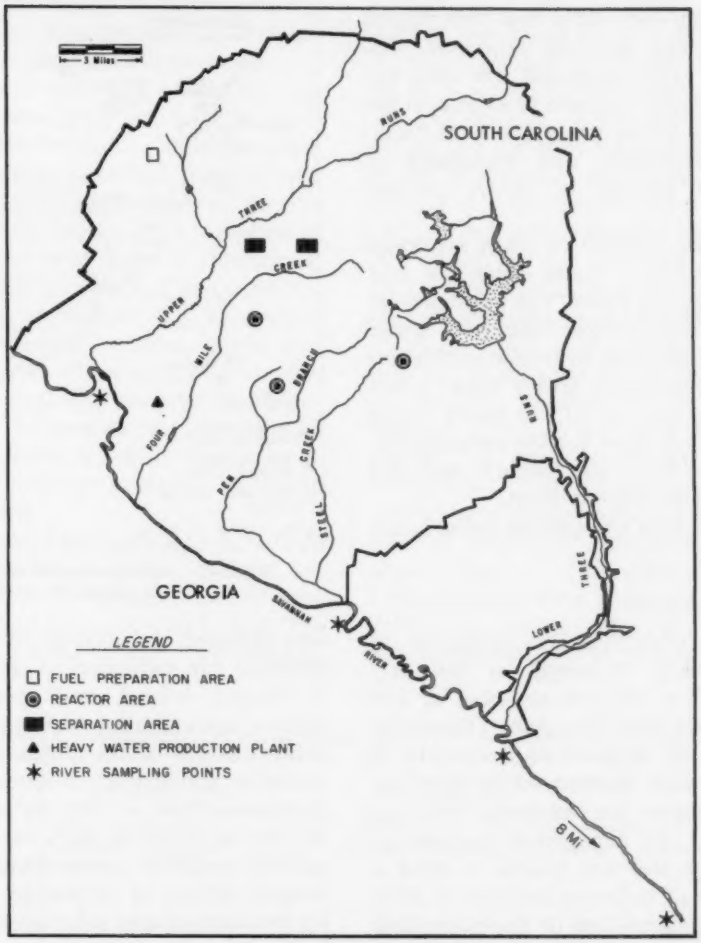

Figure 2. SRP production and effluent streams

SRP's primary function is the production of plutonium, tritium, and other special nuclear materials for the national defense, for other governmental uses, and for some civilian purposes. Production facilities now operating include three nuclear reactors, a fuel and target fabrication plant, two chemical separations plants, and a heavy water production plant. The reactors and separations plants are located near the center of the site; the other facilities near its periphery.

The reactors are fueled with uranium and moderated and cooled by heavy water which is circulated in a closed system through heat exchangers. Savannah River water and water from Par Pond, a manmade cooling lake, are used only as a secondary coolant in the heat exchangers. Water from the river or lake does not pass through the reactors, so is not subject to neutron activation.

Nuclear fuels and targets, together with other components necessary for the reactors, are manufactured in a fuel and target fabrication facility on the site. The operations are largely metallurgical and have relatively slight potential for release of radioactivity.

Reactor products are recovered in the fuel separations areas. Plutonium-239 and uranium

are separated from each other and from fission products by complex chemical processes. Plutonium-238 and californium-252 are also important SRP products that are processed in the separations areas. These areas also have facilities for the purification and packaging of tritium, and for storage of fission product wastes.

The heavy water production plant separates and concentrates heavy water from the raw water of the Savannah River. The basic process for extraction of heavy water from river water is chemical exchange with hydrogen sulfide gas at about 300 psig pressure. Heavy water is not radioactive, but a portion of the heavy water production facility is used for the reconcentration of moderator from the reactors and this heavy water contains some tritium.

SRP production area and effluent streams are shown in figure 2.

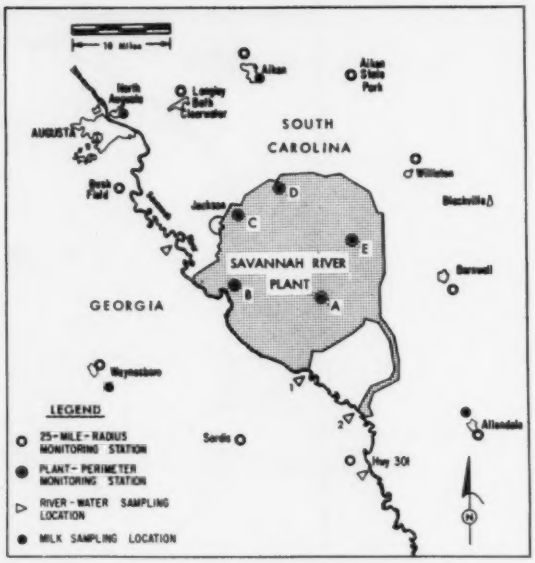

Figure 3. Environmental sampling locations Savannah River Plant

Atmospheric Monitoring

Concentrations of radioactive materials in the atmosphere are measured by biweekly analysis of air filter contents collected at five monitoring stations near the plant (figure 3). Deposition rates of radioactive materials at each station are also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). All monitoring stations operate continuously and are spaced so that a significant release of airborne activity by SRP would be detected regardless of the prevailing wind. Four additional air monitoring stations at Savannah and Macon, Ga. and at Columbia and Greenville, S.C., are so distant from SRP that the effect of SRP operations is negligible; these serve as reference points for determining background activity levels (figure 4). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between fallout and SRP releases.

Particulate airborne radioactivity is sampled continuously by drawing air through 2-inch diameter high-efficiency asbestos paper filters that are collected biweekly. The air is sampled at about 2.5 cubic feet per minute with an auxiliary running-time meter and air flow meter at each station providing data on the volume sampled. A cartridge of activated coconut charcoal for collection of gaesous radioiodine is located behind each paper filter. Moisture is concentrated from the atmosphere for determination of its tritium oxide content by pumping air through a silica gel column at a continuous rate of 100 cm^3/minute (operated off the manifold of each vacuum pump). The column contains nonindicating silica gel; a backup column of indicating silica gel is used for evidence of any saturation of the desiccant.

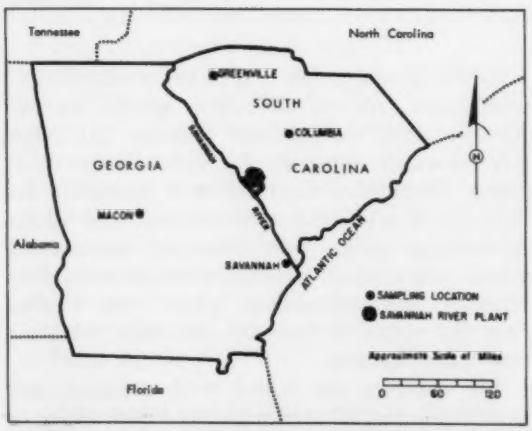

Figure 4. Distant air monitoring stations, SRP

The concentration of tritium oxide in the air is calculated from the concentration in atmospheric moisture and the absolute humidity.

Deposition rates of radioactive materials are also determined by monthly analyses of rainwater ion-exchange columns (fallout collectors). Fallout collection pans (2 feet by 2 feet) are located at each plant perimeter and 25-mile radius air monitoring station. Rain collected in the collection pan flows by gravity through an ion exchange column (cation and anion resin). The columns are analyzed directly by gamma spectrometry for gamma emitters. Alpha and beta emitters are removed from the column with acid (column elutrient) and analyzed by chemical methods. The rainwater passing through the ion exchange column is collected in a plastic jug for biweekly tritium analyses by liquid scintillation counting.

The small amount of particulate beta activity released to the atmosphere, primarily from the fuel separations area, is obscured in the area surrounding the plant by worldwide fallout. The influence of nuclear tests, which were resumed in September 1961, is shown in figure 5. The slightly increasing trend (1967 through 1971) is attributed to fallout from atmospheric testing by nonparticipants in the atmospheric testing moratorium. Some increase occurs each spring as a result of the mixing of radioactivity in the stratosphere with the troposphere. The average beta concentration in air decreased from 0.33 pCi/m³ during the first half of 1971 to 0.12 pCi/m³ during the last half of the year. The 1971 average is the same as that for 1970. The 1971 concentrations of particulate beta activity (0.23 pCi/m³) and alpha activity (0.0008 pCi/m³) in air were 0.2 percent and 4.0 percent of the AEC standards. Tritium oxide concentrations in air at the plant perimeter did not exceed 0.2 percent of the AEC standard. Iodine-131 in air samples at plant perimeter and 25-mile radius stations was less than the level of detection throughout the period (less than 1.5 percent of the AEC standard).

Gamma-emitting radionuclides observed in fallout are cesium-134, -137; cerium-141, -144; ruthenium-103, -106; and zirconium-niobium-

Table 6. Radioactivity in air, Savannah River Plant, January-December 1971

Sampling points	Alpha radioactivity [a] (fCi/m³)			Nonvolatile beta radioactivity [b] (pCi/m³)			Atmospheric moisture analysis Tritium [c] (pCi/m³)		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Plant perimeter:									
A	2.7	0.4	0.8	0.70	0.05	0.24	450	60	200
B	2.1	.3	.9	.69	.04	.22	630	60	230
C	1.6	ND	.8	.74	.05	.24	280	20	80
D	1.3	ND	.8	.86	ND	.26	440	10	120
E	1.1	ND	.8	.68	.05	.23	720	30	180
Average			0.8			0.24			162
25-mile radius:									
Aiken Airport	1.7	ND	.7	.67	.05	.22	210	10	40
Aiken State Park	1.6	ND	.7	.75	.05	.20	190	10	50
Allendale	1.5	.3	.8	.76	.04	.22	140	10	30
Barnwell	1.8	ND	1.0	.66	.04	.22	190	10	60
Bush Field	1.3	.4	.8	.76	.04	.22	170	10	40
Langley	1.7	ND	1.0	.86	.04	.25	140	10	40
Sardis	1.2	ND	.7	.68	.04	.22	130	10	30
Waynesboro	1.4	.3	.8	.75	.04	.22	170	10	50
Williston	1.5	ND	.8	.71	.04	.22	320	10	60
Highway 301	1.3	ND	.8	.73	.04	.22	120	10	40
Average			0.8			0.22			44
Distant air-monitoring:									
S.C.									
Columbia	2.4	ND	1.0	.93	.03	.23			
Greenville	1.3	ND	.8	.65	.04	.24			
Ga.									
Macon	1.8	ND	.7	.66	.03	.20			
Savannah	1.8	ND	.6	.73	.03	.22			
Average			0.8			0.22			

[a] AEC radiation protection standard, 20 fCi/m³; sensitivity of analysis, 0.3 fCi/m³.
[b] AEC radiation protection standard, 100 pCi/m³; sensitivity of anaysis, 0.005 pCi/m³.
[c] AEC radiation protection standard, 200 nCi/m³; sensitivity of analysis, 10 pCi/m³.
ND, nondetectable, less than sensitivity of analysis.

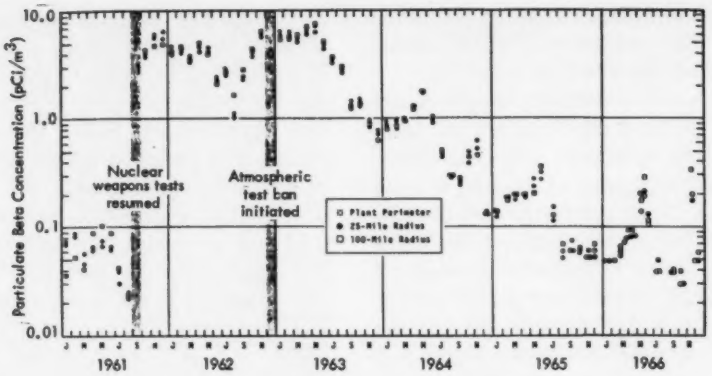

Figure 5. Influence of weapons tests

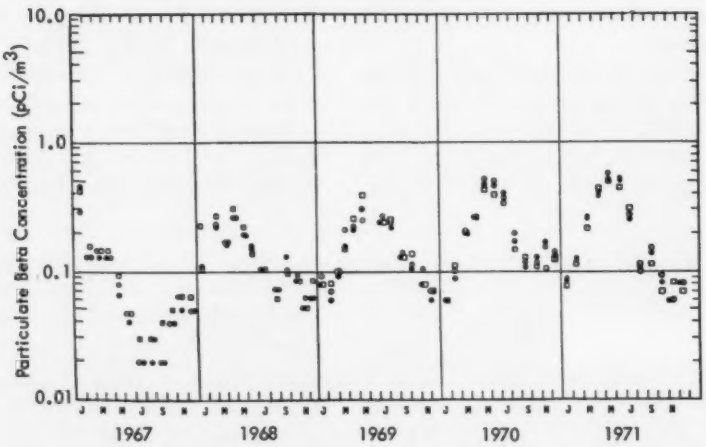

Figure 5. Influence of weapons tests—continued

95. Radioactivity in air, determined from filter analyses, is shown in table 6. The major component, beryllium-7, is a naturally occurring radionuclide formed by interaction of cosmic rays with oxygen and nitrogen in the upper atmosphere. Plant releases of airborne radioactivity, with exception of tritium, are not detectable at the plant perimeter, and concentrations are calculated using standard meteorological dispersion equations, normalized to agree with measured dispersion of tritium.

Deposition of fallout, excluding beryllium-7, during 1971 averaged 47 nCi/m² at plant perimeter locations and 47 nCi/m² at 25-mile-radius locations; comparable values for 1970 were 30 and 38 nCi/m², respectively (table 7). Rainwater is analyzed biweekly for tritium, the average concentration at the plant perimeter is 6.0 nCi/liter as compared with 1 nCi/liter at 25-mile radius stations (table 7).

Monthly measurements of gamma radiation are made with thermoluminescent dosimeters

Table 7. Total fallout deposited, Savannah River Plant, January-December 1971

Sampling points	Total fallout deposited (nCi/m²)									Tritium in rainwater [a] (nCi/liter)		
	Alpha emitters	^{89}Sr	^{90}Sr	^{137}Cs	$^{141, 144}Ce$	^{95}Zr-Nb	^{7}Be [b]	$^{103, 106}Ru$	^{131}I	Maximum	Minimum	Average
Plant perimeter:												
A	0.055	1.7	1.4	2.9	14.2	16.8	63.4	7.3	ND	16	3.0	5.0
B	.066	1.1	.9	2.4	15.7	16.3	65.3	6.8	ND	14	2.0	10
C	.071	2.2	1.3	3.1	18.9	15.9	76.4	8.1	ND	12	1.0	4.0
D	.058	2.4	1.2	2.9	14.7	17.4	60.0	7.5	0.5	15	ND	4.0
E	.065	2.3	1.4	2.9	18.9	21.1	71.9	6.1	ND	10	1.0	5.0
Average [c]	0.063	2.0	1.3	2.8	16.5	17.5	67.4	7.1	0.1			6.0
25-mile radius:												
Aiken Airport	0.074	2.2	1.6	3.3	19.8	29.6	75.4	6.5	ND	2.4	ND	1.1
Aiken State Park	.097	1.5	1.3	2.5	12.2	18.2	56.9	6.5	ND	3.7	ND	.46
Allendale	.065	2.7	1.2	2.9	16.1	24.1	64.4	5.8	ND	1.0	ND	.50
Barnwell	.064	1.8	.9	1.4	8.2	14.2	33.1	5.1	ND	4.6	ND	2.0
Bush Field	.108	.7	1.3	2.4	19.0	18.9	68.5	6.0	ND	2.2	ND	.80
Langley	.079	2.0	1.4	3.2	16.5	23.5	67.8	7.1	ND	1.1	ND	.80
Sardis	.121	1.3	1.2	2.7	12.3	25.0	50.5	5.9	ND	1.0	ND	.60
Waynesboro	.054	2.2	1.6	3.1	14.9	23.7	69.3	6.3	ND	3.0	ND	1.0
Williston	.070	2.1	1.3	2.7	13.1	19.9	61.2	5.5	ND	3.8	ND	1.8
Highway 301	.042	.8	1.4	2.1	8.7	12.6	39.7	5.8	ND	1.4	ND	.70
Average [d]	0.077	1.7	1.4	2.7	14.2	20.9	58.7	6.1	ND			1.0

[a] Sensitivity of analysis, 0.03 nCi/liter.
[b] A natural radionuclide (see foregoing section on "Atmospheric Monitoring").
[c] Average deposition of tritium, 816 μCi/m².
[d] Average deposition of tritium, 186 μCi/m².
ND, nondetectable, less than sensitivity of analysis.

at the plant perimeter and 25-mile radius locations. The 1971 environmental gamma radiation data (table 8) are characteristic measurements observed at individual stations for the past several years (—60 mR/year). SRP contribution to gamma radiation is so low as to be indistinguishable from normal variations in natural gamma radiation.

Table 8. Environmental gamma radiation, Savannah River Plant, January-December 1971

Sampling points	Gamma radiation	
	mR/day	mR/year
Plant perimeter:		
A	0.20	73.0
B	.16	58.4
C	.16	58.4
D	.16	58.4
E	.17	62.0
Average	0.17	62.0
25-mile radius:		
Aiken Airport	0.14	51.1
Aiken State Park	.14	51.1
Allendale	.14	51.1
Barnwell	.18	65.7
Bush Field	.18	65.7
Langley	.16	58.4
Sardis	.18	65.7
Waynesboro	.14	51.1
Williston	.18	65.7
Highway 301	.20	73.0
Average	0.16	59.8

Water monitoring

The SRP site is drained by five streams that flow several miles through the reservation before reaching the Savannah River (figure 2). The primary sources of the very small amount of radioactivity that reaches the river are the reactor facilities. Tritium accounts for the largest quantity of radioactivity released by the reactors to the effluent streams. However, the contribution of tritium to the Savannah River results in concentrations of only 0.2 percent of the AEC standard.

River water is sampled continuously above and below the plant and is analyzed weekly. Concentrations of alpha and nonvolatile beta emitters in river water for the past year are summarized in table 9. The upstream measurements are attributed to natural radioactivity and worldwide fallout from nuclear weapons tests. The downstream measurements reflect these sources plus releases from SRP.

Continuous sampling of the Savannah River is accomplished with a sampler consisting of a "Plexiglas" water wheel suspended on two pontoons. As the water wheel is turned by flowing water, a small cup (or cups) on one paddle picks

Table 9. Radioactivity in Savannah River water January-December 1971

Sampling points	Alpha radioactivity[a] (pCi/liter)			Nonvolatile beta radioactivity[b] (pCi/liter)		
	Maximum	Minimum	Average	Maximum	Minimum	Average
1 mile upstream from Upper Three Runs Creek (control)	0.5	ND	ND	12	ND	4
8 miles downstream from Lower Three Runs Creek at Highway 301	.6	ND	ND	13	ND	6

[a] AEC radiation protection standard, 10 pCi/liter; sensitivity of analysis, 0.2 pCi/liter.
[b] AEC radiation protection standard, 3 nCi/liter; sensitivity of analysis, 4.0 pCi/liter.
ND, nondetectable, less than sensitivity of analysis.

up a sample of water and deposits it into a trough. The sampled water flows by gravity from the trough through connecting tubing into a large polyethylene jug which trails the sampler. The sampled water (up to 6 gallons) is collected weekly at river locations above and below SRP. Increased analytical sensitivity for water samples (containing insufficient radioactivity for direct processing) is achieved through concentration of radionuclides by ion exchange. The ion exchange column is counted directly for gamma-counting radionuclides.

Tritium, and trace amounts of cesium-137, strontium-89, and strontium-90 are the only radionuclides of SRP origin detectable in river water at the downstream location. Strontium-90 and tritium from worldwide fallout are also detected in river water upstream from SRP effluents. Average concentrations of all radionuclides found in river water during 1971, as shown in table 10, are only small fractions of the AEC standards.

Drinking water

Communities near SRP get drinking water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected in April and October. Data fom analyses of all public water samples from the immediate vicinity of the plant are in table 11.

The Beaufort-Jasper Water Authority operates a treatment facility to furnish drinking water, partially obtained from the Savannah River, to most of Beaufort County, South Carolina. Water is supplied through a canal from the river at a location about 90 miles below the Savannah River Plant. A water treatment plant at Port Wentworth, Ga. supplies water to a business-industrial complex near Savannah, Ga. These two water supplies are analyzed monthly for tritium content.

There is no evidence that SRP contributes radioactivity to drinking water supplies of any of the 14 surrounding towns; concentrations of alpha activity (1.2 pCi/liter) and beta activity

Table 10. Average concentration of radionuclides in Savannah River water, January-December 1971

Radionuclide	Concentration (pCi/liter)			Percent AEC standard at Highway 301
	Sensitivity of analysis	Control (1 mile upstream from Upper Three Runs Creek)	Highway 301 (8 miles downstream from Lower Three Runs Creek)	
Tritium	300	570	5 550	0.19
Sulfur-35	5.0	ND	ND	<.01
Chromium-51	4.3	ND	ND	<.001
Manganese-54	.4	ND	ND	<.0004
Cobalt-60	1.4	ND	ND	<.005
Zinc-65	1.1	ND	ND	<.001
Strontium-89	.3	ND	.7	.02
Strontium-90	.01	.6	.9	.30
Zirconium-niobium-95	.5	ND	ND	<.001
Ruthenium-103, 106	3.2	ND	ND	<.03
Iodine-131	.2	ND	ND	<.07
Cesium-134, 137	<.01	ND	.16	.001
Barium-lanthanum-140	1.6	ND	ND	<.01
Cerium-141, 144	2.5	ND	ND	<.02
Neptunium-239	2.2	ND	ND	<.002

ND, nondetectable, less than sensitivity of analysis.

Table 11. Radioactivity in drinking water, January-December 1971

Sampling points	Source of water	Alpha radioactivity[a] (pCi/liter)		Nonvolatile beta radioactivity[b] (pCi/liter)		Tritium[c] (pCi/liter)	
		April	October	April	October	April	October
Aiken	Stream, well	2.7	0.7	6	10	750	520
Allendale	Deep well	ND	.5	ND	9	ND	ND
Augusta	River	.3	ND	ND	6	650	ND
Barnwell	Deep well	.5	ND	ND	7	ND	ND
Bath	Lake	1.8	ND	6	ND	ND	ND
Blackville	Deep well	.5	.3	ND	ND	ND	ND
Clearwater	Lake	.7	.3	ND	ND	650	850
Jackson	Deep well	8.2	5.9	18	15	ND	ND
Langley	Stream	3.6	2.0	7	10	430	ND
New Ellenton	Deep well	1.3	1.0	ND	6	ND	ND
North Augusta	River	.4	ND	ND	7	500	ND
Sardis	Deep well	ND	ND	4	6	ND	ND
Waynesboro	Stream	ND	ND	8	6	580	ND
Williston	Deep well	2.2	.8	4	9	ND	ND
Average[d]		1.6	0.9	6	7		

[a] AEC radiation protection standard, 30 pCi/liter; sensitivity of analysis, 0.2 pCi/liter.
[b] AEC radiation protection standard, 3 nCi/liter; sensitivity of analysis, 4.0 pCi/liter.
[c] AEC radiation protection standard, 3 μCi/liter; sensitivity of analysis, 300 pCi/liter.
[d] Averages are calculated using sensitivity values for those individual items that were less than the sensitivity of their analysis.
ND, nondetectable, less than sensitivity of analysis.

(7 pCi/liter) are essentially the same as those observed before plant startup. The higher than average alpha activity (7.0 pCi/liter) at Jackson is attributed to naturally occurring radioactivity, primarily thorium-228 and its short-lived daughter products. Very low levels of tritium are found in drinking water of several of the towns that use surface water (maximum of 750 pCi/liter). Concentrations of tritium in water from deep wells are less than the sensitivity of the analyses (300 pCi/liter).

Milk

Milk is sampled at four dairies within a 25-mile radius of SRP, as shown in figure 2. Samples are collected biweekly and analyzed for tritium and radioiodine. Analyses are made quarterly for strontium-90 and monthly for cesium-137. Milk produced in the area and sold by major distributors is also analyzed for these radionuclides. Results from analyzing milk for radioactivity during 1971 are summarized in table 12.

Strontium-90 and cesium-137 in milk are attributed to fallout. Average concentrations of the radionuclides in milk were 10 pCi/liter of strontium-90 and 15 pCi/liter of cesium-137. Iodine-131 in milk samples was less than the sensitivity of the analysis (1 pCi/liter) throughout the report period. The strontium, cesium, and iodine values—which are consistent with

Table 12. Radioactivity in milk from local dairies, Savannah River Plant, January-December 1971

Local dairies	Concentration (pCi/liter)								
	Tritium[a]			Strontium-90[b]			Cesium-137[c]		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Aiken	960	ND	425	16	7	10	20	4	12
North Augusta	4 700	ND	1 125	26	15	19	30	4	17
Waynesboro	2 000	ND	800	8	5	6	20	4	12
Barnwell	5 500	ND	2 300	12	10	11	26	9	17
Major distributors[d]	1 500	ND	680	11	8	9	27	1	15

[a] AEC radiation protection standard, 3 μCi/liter; sensitivity of analysis, 300 pCi/liter.
[b] AEC radiation protection standard, 300 pCi/liter; sensitivity of analysis, 1.0 pCi/liter.
[c] AEC radiation protection standard, 20 nCi/liter; sensitivity of analysis, 1 pCi/liter.
[d] Milk produced in local dairies but sold by major distributors.
ND, nondetectable, less than sensitivity of analysis.

those reported by the U.S. Public Health Service for most sections of the United States (*1*)—represent 3.3, 0.07, and 0.3 percent of the respective AEC standards for water. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level (1 300 pCi/liter) is 0.04 percent of the AEC standard for water.

Vegetation

Radioactive contamination of growing plants may result from sorption of radioactive materials from the soil or from foliar deposition. Bermuda grass is selected for analysis because of its importance as a pasture grass for dairy herds and its availability during all seasons of the year.

Grass samples are routinely collected at seven locations along the plant perimeter and at seven other locations along a 25-mile radius route. Samples from each quadrant of the plant and of the surrounding area are composited for monthly analysis. Gamma-emitting radionuclides in grass samples (excluding beryllium-7) are from weapons tests fallout. Alpha emitters averaged 0.15 pCi/g at the plant perimeter and at the 25-mile radius locations, the same as during 1970; gamma emitters averaged 24 pCi/g as compared to 15 pCi/g for 1970. Radioisotopic concentrations found in grass samples are presented in table 13.

Farm produce

Sixty samples of farm produce representing four food categories (grain, fruit, poultry, and leafy vegetables) are collected at 14 locations in the 6 counties surrounding SRP during the summer and fall of each year. Two samples of local beef were also collected from Waynesboro, Ga. All samples were analyzed by gamma spectrometry for cerium-144, iodine-131, ruthenium-103, ruthenium-106, cesium-137, and manganese-54. Radiochemical analyses are used for strontium-90 and alpha emitters (uranium and plutonium), and liquid scintillation counting for tritium. With exception of grains, all

Table 13. Radioactivity in vegetation, January-December 1971

Sampling points	Concentration (pCi/g dry weight)											
	Alpha emitters [a]		^{137}Cs [b]		$^{141, 144}Ce$ [c]		$^{103, 106}Ru$ [d]		^{95}Zr-Nb [e]		^{7}Be [f]	
	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average
Plant perimeter (7 locations)	1.1	0.15	3.8	1.4	27.5	7.7	4.4	1.6	11.0	2.8	35.5	10.4
25-mile radius (7 locations)	.7	.15	1.1	.7	14.1	6.4	5.0	2.2	5.2	2.5	23.1	11.0

[a] Sensitivity of analysis, 0.10 pCi/liter.
[b] Sensitivity of analysis, 0.3 pCi/liter.
[c] Sensitivity of analysis, 1.0 pCi/liter.
[d] Sensitivity of analysis, 1.4 pCi/liter.
[e] Sensitivity of analysis, 0.5 pCi/liter.
[f] Sensitivity of analysis, 3.0 pCi/liter. A natural radionuclide.

Table 14. Radioactivity in agricultural products, January-December 1971

Media	Number of samples	Concentration (pCi/g wet weight)										Tritium [f] (nCi/liter)	
		^{90}Sr [a]		$^{141, 144}Ce$ [b]		^{95}Zr-Nb [c]		^{137}Cs [d]		Alpha emitters [e]			
		Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average
Collards	14	0.50	0.30	ND	ND	ND	ND	0.10	0.03	0.024	0.004	30	7.6
Plums	14	.16	.05	0.22	ND	ND	ND	ND	ND	.004	.002	9	4.1
Oats, rye, and wheat	14	.25	.12	.22	ND	0.18	ND	.10	.05	.006	ND	26	4.9
Corn	14	.07	.03	ND	ND	ND	ND	.12	.06	.002	ND	9	4.5
Chicken	4	.10	.07	ND	ND	ND	ND	ND	ND	.005	.002	5	3.8
Beef	2	NA	NA	NA	NA	NA	NA	.04	.04	NA	NA	1	1.4

[a] Sensitivity of analysis, 0.02 pCi/liter.
[b] Sensitivity of analysis, 0.06 pCi/liter.
[c] Sensitivity of analysis, 0.02 pCi/liter.
[d] Sensitivity of analysis, 0.02 pCi/liter.
[e] Sensitivity of analysis, 0.002 pCi/liter.
[f] Sensitivity of analysis, 1.0 pCi/liter. Concentration in free water.
ND, nondetectable, less than sensitivity of analysis.
NA, no analysis.

foods are prepared for analysis in a manner similar to that used to prepare them for human consumption. Peelings, seeds, and other nonedible parts are removed. Wheat containing the whole grains only, and oats containing both grains and husks, are processed unwashed. Results are summarized in table 14. Concentrations in some samples are too low for reliable measurement, and only the results above the detection limit of the analyses are included.

SRP contributions to the levels of radioactivity (excluding tritium) in farm produce were so low in 1971 that they were indistinguishable from fallout. All radionuclides in food are near or below the levels of detection. Results of strontium-90 are about the same as in the 1970 samples with the highest concentration again in collards (0.5 pCi/g). Tritium concentrations in foods are similar to those found in rain water, with maximum value (30 nCi/liter) in samples collected near the plant perimeter.

Fish

Fish traps are maintained in the Savannah River, upstream, adjacent to, and downstream from the SRP effluents. Individual whole fish are analyzed by gamma spectroscopy for cesium-137 and other gamma emitting radionuclides; bone from each specimen is composited monthly for strontium-89 and strontium-90. Fish analysis data are presented in table 15.

The radioactivity in bone and flesh of fish shows some measurable contribution by SRP, but concentrations are of minor significance from a radiation dose viewpoint. An adult regularly consuming fish from the river adjacent to SRP (at a rate of 25 pounds/year) would receive a whole-body dose of only 2.7 mrem as compared to approximately 125 mrem from natural radiation.

Deer

Concentrations of cesium-137 in 865 deer and 8 hogs killed during the autumn 1971 hunt were estimated with a portable, single-channel scintillation instrument before release of the animals to the hunters. The estimated cesium-137 content was verified by gamma spectroscopic analysis of muscle tissue of 135 deer. Deer and hog analysis data are shown in table 16.

Cesium-137 concentrations in deer are well within the range of concentrations found in deer killed in similar terrain through the southeast. The cesium presumably originated almost entirely from that deposited by fallout from nuclear weapons tests. The average cesium-137 concentration in deer was 11 pCi/g with a maximum of 48 pCi/g. Edible meat from the deer containing 48 pCi/g would weigh about 40 pounds and would therefore contain about 0.87 Ci of cesium-137. An adult eating all of this deer meat would receive a radiation dose of 50 mrem to the whole body, 40 percent of the annual dose South Carolina residents receive

Table 15. Radioactivity in Savannah River fish, January-December 1971

Location	Number of fish assayed		Type of sample	Concentration (pCi/g wet weight)					
				Cesium-137				Strontium-89, -90	
	Bream [a]	Catfish [b]		Bream [a]		Catfish [b]		Bream and catfish	
				Maximum	Average	Maximum	Average	Maximum	Average
Above SRP boundary	59	115	Bone	NA	NA	NA	NA	23	10
			Flesh	25	2.2	15	2.0	NA	NA
Adjacent to SRP	23	55	Bone	NA	NA	NA	NA	21	11
			Flesh	18	4.2	21	4.0	NA	NA
Below SRP at Highway 301	175	63	Bone	NA	NA	NA	NA	14	8
			Flesh	20	2.8	11	2.9	NA	NA

[a] Shellcracker, bluegill, and redbreast (*Lepomis*).
[b] Predominantly yellow cat (*Ictalurus*).
NA, no analysis.

Table 16. Radioactivity in deer and hogs January-December 1971

Number of animals	Species	Cesium-137 in flesh (pCi/g wet weight)	
		Average	Range
865	Deer	11	<1-48
8	Hogs	10	6-19

from natural radiation (*2*). Radiozinc (zinc-65) is the only other gamma-emitting radionuclide detected in deer tissue; a maximum of 6 pCi/g was found in one of three deer showing zinc-65.

Summary

A continuous monitoring program has been maintained since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1200-square mile area outside the Savannah River Plant. Included are parts of Aiken, Barnwell, and Allendale counties in South Carolina; and Richmond, Burke, and Screven counties in Georgia. Although very small amounts of gaseous and liquid radioactive materials are discharged to the environment, environmental levels continue to be far below levels considered significant from a public health viewpoint.

The quantity of radioactivity released by SRP to its environs during 1971 is, for the most part, too small to be distinguished from natural background radiation and fallout from worldwide nuclear weapons tests. Particulate beta radioactivity detectable in air is due entirely to global fallout. This concentration in air at the plant perimeter and 25 miles away represents 0.2 percent of the AEC standard. Tritium oxide in air at the plant perimeter is greater than in air at more distant locations. The average concentration at the plant perimeter, only 0.1 percent of the AEC standard, is the largest percentage of any AEC air standard for plant-released radionuclides.

Tritium, cesium-137, strontium-89, and strontium-90 are the only radionuclides of plant origin detectable in river water. None of these had an average concentration that exceeded 0.2 percent of the AEC standard in river water sampled 8 miles downstream from the plant. Radioactive materials in river fish also continue to be very low. Various water quality analyses of river water samples surveyed by SRP indicate that Savannah River water is not adversely affected by SRP operations. This is substantiated by surveys of the health of the Savannah River biota by the Academy of Natural Sciences of Philadelphia.

REFERENCES

(*1*) ENVIRONMENTAL PROTECTION AGENCY. Radiation Data and Reports (monthly publication). Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*2*) ENVIRONMENTAL PROTECTION AGENCY. Background levels by States. Fuel News, Vol. 15, No. 1 (January 1972).

Previous coverage in *Radiation Data and Reports:*

Period	Issue
January–June 1971	March 1972

Reported Nuclear Detonations, January 1974

(Includes seismic signals presumably from foreign nuclear detonations)

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States on January 30, 1974. The signals originated at the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 20-200 kilotons.

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A RADIOACTIVE ISOTOPE CHARACTERIZATION OF THE ENVIRONMENT NEAR WISCASSET, MAINE; A PREOPERATIONAL SURVEY IN THE VICINITY OF THE MAINE YANKEE NUCLEAR REACTOR. *Dr. C. T. Hess, Dr. C. W. Smith, H. A. Kelley, and F. C. Rock. Radiation Data and Reports. Vol. 15,* February 1974, pp. 39–52.

An environmental radioactivity survey was conducted in the vicinity of the Maine Yankee Nuclear Power Station prior to the operation of this facility. Measurements of environmental radioactivity were made on samples of soil, sediment, well water, surface water, estuarine water, air particulates, air moisture, and precipitation.

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